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Introduction.

AS the announcement in the January number of "KNOWLEDGE" will have led our readers to expect, certain new features appear in this the first issue of the combined papers "KNOWLEDGE & ILLUSTRATED SCIENTIFIC NEWS." These features, which were characteristic of the younger of the two periodicals, take the form of articles on Physics and Applied Science; and if they prove acceptable to our readers, we propose to add to them as time goes on other articles and notes dealing with the progress of science in Chemistry and Electricity. At the same time it is proposed to discontinue none of the features which have been distinctive of "KNOWLEDGE," and which during many years have secured for it so large and influential a body of readers. All the contributors whose names were mentioned in the forecast which was published last December of the forthcoming volume of "KNOWLEDGE" have been retained, and their articles will appear during the ensuing twelve months. The Astronomical columns and their editorship will remain under the able direction which has controlled them hitherto; and the general articles and notes on Botany, Zoology, and Natural History will remain unchanged in general form and substance. The publication of the columns on Chess alone, it is proposed, owing to unavoidable circumstances, to postpone from this month until next, when a new announcement will be made. In concluding this brief notice of our intentions, we may express the hope that they are such as to meet with the approval of our readers.

Ancient Calendars and Constellations.

By E. WALTER MAUNDER, F.R.A.S.

IT is generally asserted that the months of the year, both of the Accadian and Assyrian calendars, have an intimate connection with the constellations of the Zodiac; the great epic of Gilgamesh has been claimed as a zodiacal myth; and other myths and legends are explained in the same manner, or contain references which are apparently constellational. But we are thus sometimes involved in grave chronological difficulties, of which Assyriologists for the most part have taken no notice. It is therefore a very real service to science which the Hon. Miss Emmeline M. Plunket has rendered,* in that she has recognised one of the most serious of these discrepancies, has called attention to it, and has striven to remove it.

The chief astrological work of Assyria is one in 70 tablets, drawn up for the library of King Sargon of Agané. The date at first assigned to this monarch was about 1700 B.C., for it was concluded that before this date the month Nisan, the first month of the Assyrian calendar, could not have corresponded with the position of the spring equinox in the first sign of the Zodiac, Aries. Later, however, a baked clay cylinder of Nabonidus, King of Babylon, who reigned from 555—538 B.C., was discovered, in which he described how he rebuilt the temple of the sun god at Sippar, and in the course of the work had found an inscription of Narâm-Sin, the son of Sargon I., the original founder of the temple, "which for 3200 years had not been seen." From this tablet a little simple arithmetic led to the conclusion that the date of Sargon must have been about 3800 B.C.

These two determinations of the date of Sargon differ, it will be seen, by at least two thousand years; that is to say, by more than the entire length of the Christian era. The second determination of course follows inevitably, if we take the statement of Nabonidus at its face value. The first determination is equally inevitable if certain underlying assumptions are made. But both determinations cannot be right; a period of 2000 years cannot be treated as a negligeable quantity. Assyriologists in general stand by the date for Sargon of 3800 B.C. as "the best determined date in ancient history." Yet the obvious consequence has not been recognised, or at least not been practically admitted; namely, that the assumptions upon which the date of 1700 B.C. were based must, some or all of them, be incorrect. They still sometimes enter, explicitly or implicitly, into Assyriological papers without the slightest hint being afforded that so grave a doubt has been cast on their validity.

The assumption with which Miss Plunket deals is the one that the Accadian year originally began with the sun's entry into the zodiacal constellation Aries at the spring equinox. For spring equinox she would substitute winter solstice, and thus throw back the origin of the Accadian Calendar by 6400 years, to some date prior to the year 6600 B.C.

This suggestion is the text of Miss Plunket's book, which consists of eight papers communicated at different times to the Society of Biblical Archæology, followed by notes explaining the numerous illustrative plates. She applies this principle to the explanation of the astronomy and mythology of Assyria, Media, Egypt, India, and China, displaying much research and not a little ingenuity in some of her explanations.

* "Ancient Calendars and Constellations." By the Hon. Emmeline M. Plunket. (John Murray.)

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But it is not necessary to examine her arguments in detail. The objections to her fundamental principle are too serious. In the first place we may be very confident that the starting point of the original year was not fixed at a solstice. The difficulty to the first beginners in astronomical observation of determining the solstice must have been very great. For more than an entire month the sun does not alter its declination by a single degree; its places of rising and setting, its height at noon, show scarcely any change. But when we turn to the equinoxes we find a very different state of things. At that time three days make a greater difference in the sun's declination than thirty at the solstice. The height of the sun at noon changes from one day to the next by three-fourths of the sun's diameter. The most careless observers could not fail to recognise that either equinox was a point of time which could be determined with very great ease and precision. At these times of the year, too, and at these alone, the place of sunrise is precisely opposite the place of sunset. By half-a-dozen methods, all of the greatest simplicity, the time of the equinox could be fixed to a day.

Then it is not the case, as Miss Plunket avers, that Aries was the traditional constellation to lead the year. It is curious that some of the traditions which speak of a time when Taurus opened the year are expressly quoted by Miss Plunket. The familiar lines of Virgil in the first Georgic are an instance. Prof. Sayce, in the very same paper as that which Miss Plunket takes as her authority, quotes Ernest de Bunsen, "That Scorpio was taken as the starting point of the primitive Calendar," and Scorpio, of course, holds the same position with regard to the autumnal equinox that Taurus, not Aries, does to the vernal.

Miss Plunket, at the beginning of her fourth chapter, recognises that the great importance of Tauric symbolism in Median art seems to point to the fact that when the equinoctial year was first established, the spring equinoctial point was in the constellation Taurus, and she quotes Cumont to show that the great festivities in honour of Mithra were, as a rule, celebrated at the season of the spring equinox. Most opportunely a translation by Mr. Thomas J. McCormack has just appeared of Cumont's "Mysteries of Mithra," in which he gives a clear and most interesting account of the cult of Mithraism and of its distribution in Europe.* The illustrations of the book render one fact of Mithraism very conspicuous; its intimate connection with the constellational figures, and especially with the signs of the Zodiac. In particular, the Bull, the Scorpion, the Lion, and the Man, the four constellations of the colures when Taurus held the vernal equinox, are the great Mithraic symbols. Yet most of these symbols extant were actually carved in the second century A.D., when their appropriateness to the four seasons had been completely lost.

But the vital objection to Miss Plunket's theory is that it assigns to the constellations an antiquity greater by some thousands of years than they can possibly possess. This is a point I have already taken up elsewhere, and I need only summarise the arguments here:—

(1) The centre of the space not included in the ancient constellations must have been the south pole of the period when they were designed. This gives roughly the date 2800 B.C.

(2) This date accords with the tradition of the four Royal stars—Aldebaran, Regulus, Antares, Fomalhaut—marking the original colures.

(3) It gives the only symmetrical position for the actual constellations of the Zodiac.

(4) The ascending signs at this date faced east, the descending west.

(5) As shown above, there are traditions of Taurus leading the Zodiac; but there are none of Gemini, Cancer, or of any earlier sign.

Thus as to season and constellation and date, we must find Miss Plunket in error. But beside this error in principle there are several errors in detail, either as to astronomical fact or in computation.

Thus, for example, we find in the preface, p. viii., the times when the equinox entered Aries and Taurus, quoted from Prof. Sayce, as 2540 and 4698 B.C. respectively, but on p. 66 and elsewhere these dates are given as 2000 and 4000. These are not the only instances of a considerable looseness in dealing with the subject of precession. Thus, on page 37, Miss Plunket speaks of the stars of Aries attaining the southern meridian at midnight, two months after the summer solstice, between the years 1100 and 1400 B.C. Actually the constellation Pisces held that position. On pp. 166 and 167 the star Spica is said to have been in opposition to the sun on the 14th night of the first month at the time of the Exodus. This fixes the date of the Exodus as about 1300 years *after Christ*, *i.e.*, in the time of the Plantagenets!

There should be no very great difficulty in understanding the effect of precession. If we take the entire precessional period as 25,800 years, we find that the longitude of any star must increase one degree in $71\frac{8}{43}$ years. It is then a matter of the very simplest arithmetic to find out what star at any time was on the equinoctial colure, that is to say in zero longitude, and what were the longitudes of other stars.

So far from Aries having been the equinoctial sign as early as 2540 B.C., the first zodiacal star of the constellation about which we can be at all sure did not hold that position till 1650 B.C. The equinoctial point was still in the Pleiades—undoubtedly a portion of Taurus—as late as 2200 B.C., and Aldebaran, "the eye of the Bull," and the very central star of the constellation, was on the colure 3000 B.C. The earliest undoubted bright star of Taurus, Zeta Tauri, the tip of the southern horn, was in zero longitude 4080 B.C.

We can see at once why we have no tradition of the constellation of the Twins opening the year. The constellations were certainly mapped out much later than 4080 B.C. But the real difficulty, and it is a very important one, is to explain how it was that Aries came to be looked upon as the first sign at a comparatively early date. If we take the date 1650 B.C., for instance, the sun was then in conjunction with Delta Arietis (a star but little brighter than the 5th magnitude) at the spring equinox. But it was also in conjunction at the same date with Xi Tauri and Omicron Tauri, considerably brighter stars, and for practically one full month after the spring equinox the sun would be travelling through Taurus. It is not possible to conceive that at this period, when men had always from the very first beginning of astronomy been accustomed to regard Taurus as the first sign, they decided to give the primacy to Aries. It would be so easy for them still to consider Taurus as reaching to this point, which indeed it overlaps, and on any view, even if they considered the sun as in Aries on the actual first day of spring, four days later it would be unmistakably in Taurus. Practically the sun at the spring equinox was still at the first point of Taurus, and there was no need to make any change of the first sign.

* "The Mysteries of Mithra." By Franz Cumont. Translated by T. J. McCormack. (Chicago: The Open Court Publishing Co. London: Kegan Paul.)

Yet we may be sure that it would be only under something like compulsion that the change would be made, for we see how tenacious men are of old traditions by our own case, since we still speak of the first point of Aries, although the equinox has almost traversed the entire length of Pisces. It is almost universally forgotten that it was not until the equinox had been brought by the effect of precession right through a sign, to its very boundary, that that particular sign was in its true position to correspond with the first month of the year. The equinoctial point moves through the centuries by the effect of precession in the direction of diminishing longitudes; the sun in its annual course through the year moves in the direction of increasing longitudes.

It could not have been early, therefore, in the period which precession would ascribe to Aries that the primacy was transferred to that constellation. It is scarcely conceivable that it can have been before Hamal, the *lucida* of the constellation, had reached the colure, which it did about 700 B.C. There are no bright stars between Delta Arietis and Hamal; there is nothing whatsoever to have compelled an abandonment of a primeval custom. Indeed, it seems to me that there is only one theory by which we can account for the transference of the dignity of leader from the Bull to the Ram. If in the course of time the science of astronomy fell into abeyance, possibly through wars and revolutions and the conflicts of races, and all that remained was just the recognition of the old constellation forms which might well have been preserved by the peasantry, and then at a later date the science was built up anew, the position of Aries as the leader constellation would be perfectly natural. But if so, whilst we must take 2800 B.C., or perhaps, to speak in rounder numbers, 3000 B.C., as the time of the rise of the first astronomy, with Taurus as leader, the time of its revival with Aries as leader can hardly have antedated 700 B.C.

If, then, we find a poem or myth, evidently based upon the Ram-Zodiac, we may be fully assured that the date of its first origin was certainly not earlier than 700 B.C., and probably considerably later. For a myth is not likely to have taken thorough hold upon men's imaginations immediately after the acceptance of a novel scientific system, to explain which that myth had been imagined. Such a process is necessarily one of slow development.

I will take but one illustration; the epic of Gilgamesh has been sometimes claimed as a solar legend on account of a supposed connection between the twelve successive tablets which contain it, and the twelve signs of the Zodiac. The hero is the sun, and the epic describes his progress through the twelve signs in the course of a year, the eleventh tablet which gives the account of the Deluge corresponding to the constellation Aquarius, the eleventh sign of the Ram-Zodiac. But Assyriologists would not be willing to admit that the Deluge Story was no older than the eighth century B.C. It follows, therefore, that the original Deluge poem must have been written when Aquarius was the tenth sign of the Zodiac, so that the legend cannot be interpreted as a poetic expression of the constellation figure. What applies to one sign applies to the rest, and the entire correlation imagined between epic and Zodiac breaks down at every point.

The question on which we have no light at present is as to the steps of the evolution, or the character of the catastrophe by which the Bull-Zodiac was superseded by the Ram-Zodiac. We can only be sure of one point, that, given the connection between the constellations and the months of the year which is usually assumed, then the Ram-Zodiac must be of comparatively modern times; later, probably a good deal later, than 700 B.C.

A Motor Aeroplane.

Successful Trials with a Man-Carrying Machine.

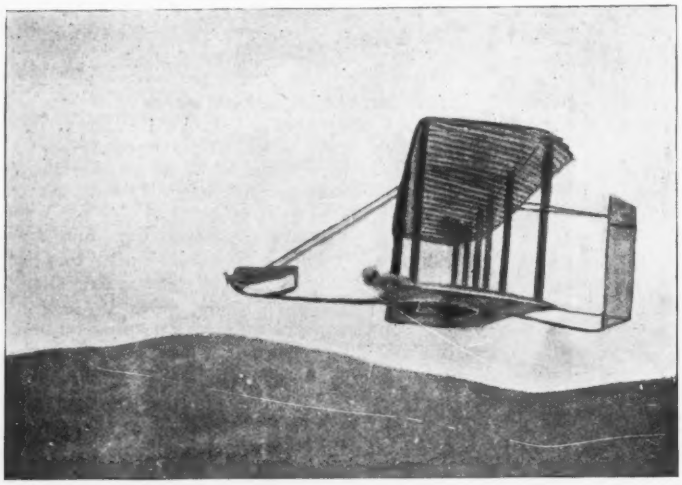
MANY of our readers have doubtless been keenly interested in some of the experiments now being conducted in England, and especially in America, with flying machines. Hitherto but little success has attended the efforts of inventors, and though on a few occasions a model has shown its power of progressing through the air, yet all attempts to raise a man from the ground have proved abortive.

Various vague and sensational accounts have appeared in the Press during the last few weeks of a most important experiment made in America by the brothers Wright. We are now able to give an authentic account, kindly sent by Mr. Orville Wright himself, of what actually occurred. He states that he had not intended at present making any public statement with regard to the trials, but that "newspaper men" gave out "a fictitious story incorrect in almost every detail," so that the inventors feel impelled to make some corrections. The real facts were as follows:—

On the morning of December 17, between the hours of 10.30 o'clock and noon, four flights were made, two by Orville Wright and two by Wilbur Wright. The starts were all made from a point on the levels and about 200 feet west of our camp, which is located a quarter of a mile north of the Kill Devil sand hill, in Dare County, North Carolina. The wind at the time of the flights had a velocity of 27 miles an hour at 10 o'clock, and 24 miles an hour at noon, as recorded by the anemometer at the Kitty Hawk weather bureau station. This anemometer is 30 feet from the ground. Our own measurements, made with a hand anemometer at a height of four feet from the ground, showed a velocity of about 22 miles when the first flight was made, and 20½ miles at the time of the last one. The flights were directly against the wind. Each time the machine started from the level ground by its own power alone with no assistance from gravity, or any other sources whatever. After a run of about 40 feet along a mono-rail track, which held the machine eight inches from the ground, it rose from the track and under the direction of the operator climbed upward on an inclined course till a height of eight or ten feet from the ground was reached, after which the course was kept as near horizontal as the wind gusts and the limited skill of the operator would permit. Into the teeth of a December gale the "Flyer" made its way forward with a speed of ten miles an hour over the ground and 30 to 35 miles an hour through the air. It had previously been decided that for reasons of personal safety these first trials should be made as close to the ground as possible. The height chosen was scarcely sufficient for manœuvring in so gusty a wind and with no previous acquaintance with the conduct of the machine and its controlling mechanisms. Consequently the first flight was short. The succeeding flights rapidly increased in length, and at the fourth trial a flight of 59 seconds was made, in which time the machine flew a little more than a half mile through the air, and a distance of 852 feet over the ground. The landing was due to a slight error of judgment on the part of the operator. After passing over a little hummock of sand, in attempting to bring the machine down to the desired height, the operator turned the rudder too far, and the machine turned downward more quickly than had been expected. The reverse

movement of the rudder was a fraction of a second too late to prevent the machine from touching the ground and thus ending the flight. The whole occurrence occupied little, if any more, than one second of time.

Only those who are acquainted with practical aeronautics can appreciate the difficulties of attempting the first trials of a flying machine in a 25-mile gale. As winter was already well set in, we should have postponed our trials to a more favourable season, but for the fact that we were determined, before returning home, to know whether the machine possessed sufficient power to fly, sufficient strength to withstand the shock of landings, and sufficient capacity of control to make flight safe in boisterous winds, as well as in calm air. When these points had been definitely established, we at once packed our goods and returned home, knowing that the age of the flying machine had come at last.



A Wright Machine—A side view.

From the beginning we have employed entirely new principles of control; and as all the experiments have been conducted at our own expense, without assistance from any individual or institution, we do not feel ready at present to give out any pictures or detailed description of the machine.

It may be mentioned that the Messrs. Wright have for some years been conducting a series of experiments with "gliding machines," that is to say aeroplanes without any engine or propeller. With them the operator starts from the top of a hill and glides down through the air to the bottom, thus having to balance and control the machine.

We give here an illustration of one of the gliders, which is probably very similar to the machine recently tried, but the latter apparently had a motor and propeller added.

Electrical Novelties.

Messrs. F. Darton and Co.'s list of electrical novelties, just published, is remarkable for the cheapness of most of the articles which this firm supplies. The novelties include house telephones, hand gears and hand-geared dynamos for demonstration purposes, and their well-known small dynamos for working with small oil engines. This firm also has a number of attractive small electric light sets and economical motors for fans and light electric power work.

Giant and Miniature Suns.

By J. E. Gore, F.R.A.S.

It was at one time thought a probable hypothesis that the stars were in general of approximately equal size and brightness, and that their difference in brilliancy depended chiefly on their relative distance from the earth. On this apparently plausible hypothesis, we should have —taking the accepted "light ratio" of 2·512—an average star of the first magnitude equal in brightness to 100 stars of the sixth magnitude. As light varies inversely as the square of the distance, this would imply that a star of the sixth magnitude —that is one just steadily visible to average eyesight in a clear and moonless sky—would be ten times farther from the earth than a star of the first magnitude. For the same reason, a star of the eleventh magnitude would be at ten times the distance of a star of the sixth magnitude, and therefore 100 times the distance of one of the first magnitude. An eleventh magnitude star is about the faintest just steadily visible with a telescope of 3 inches aperture. For stars of the sixteenth magnitude, or about the faintest visible in a 25-inch refractor, the distance would be—on the above hypothesis—1000 times the distance of a first magnitude star.

Although this hypothesis was plausible enough at first sight, there never was any real evidence to show that the stars are of equal size and brightness, and modern researches have proved that they differ greatly in absolute size, and also in intrinsic brilliancy of surface. Measures of distance have shown conclusively that several small stars are considerably nearer to us than some bright stars, such as Arcturus, Vega, Capella, Rigel, and Canopus. These brilliant orbs must therefore be vastly larger than the faint stars which show a larger parallax. On the other hand, we have reason to believe that many stars are much smaller than our Sun. A consideration of some of these giant and miniature suns, as they may be termed, may prove of interest to the general reader.

We will first consider some of the "giant" suns. The well-known reddish star Aldebaran (α Tauri) in the Hyades may be taken as a standard star of the first magnitude. A small parallax of 0·107 of a second of arc was recently found for it at Yale College Observatory (U.S.A.). This makes its distance from the earth about seven times that of α Centauri (of which the parallax is 0″·75). Now, as Aldebaran has the same spectrum (K 5 M, Pickering) as the fainter component of α Centauri (magnitude 1·75), the two stars may be considered as fairly comparable in intrinsic brightness. From the above data I find that Aldebaran is about 92 times brighter than the companion of α Centauri and its mass about 882 times greater. But the components of α Centauri are of equal mass, and each equal in mass to our Sun. Hence Aldebaran has probably a mass 882 times greater than that of the Sun!

The red southern star Antares (α Scorpii) is of magnitude 1·22, according to the most recent measures at Harvard Observatory, and its parallax, according to Sir David Gill, is about 0″·021. Comparing with Aldebaran, we have the latter 1·159 times brighter. But Antares is at five times

the distance of Aldebaran. Hence the real brightness of Antares will be $\frac{5^2}{1\cdot159}$, or 21·5 times greater than that of Aldebaran. The surface of Antares would therefore be 21·5 multiplied by 92, or 1978 times the surface of the companion of α Centauri, and its mass about 88,000 times the mass of the Sun—a truly giant orb!

Betelgeuse (α Orionis) has a similar spectrum to Antares, but as it is brighter and its distance greater it is probably larger still.

Rigel (β Orionis). Assuming a parallax of 0″·01 found by Sir David Gill, and comparing it with the *brighter* component of α Centauri, which is of nearly the same apparent (or stellar) magnitude, we have, since the parallax of α Centauri is 0″·75,

Light of Rigel $= 75^2 = 5625$ times light of the Sun (which is probably the same as that of α_2 Centauri). But the spectrum of Rigel shows that it is hotter and brighter than our Sun. The two bodies are therefore not exactly comparable, and we must make an allowance for their difference in intrinsic brightness. If we assume that the Sun's light is reduced by absorption in its gaseous surroundings to one-fourth of its real light — which is probably a liberal allowance—we have,

$$\text{Surface of Rigel} = \frac{5625}{4} = 1406 \text{ times surface of Sun.}$$

From this it would follow that the volume of Rigel is about 52,000 times that of the Sun. Rigel is, however, probably of less density than our Sun, owing to its higher temperature. Comparing it with Algol, which has a similar spectrum, and of which the density and mass are known, we have the surprising result that the mass of Rigel is about 20,000 times the mass of the Sun! The parallax of Rigel is, of course, somewhat doubtful, but Sir David Gill is confident that it does not *exceed* the small quantity above stated.

For β Centauri, Gill found a parallax of 0″·046. Placed at the distance indicated, the Sun would shine as a star of about 6·75 magnitude, and as the photometric magnitude of the star is 0·86, we have a difference of 5·89 magnitude, which would make β Centauri 227 times brighter than the Sun. This gives a volume 3420 times the Sun's volume, and assuming the density at one-fourth of the Sun's, we obtain a mass for β Centauri equal to 855 times the Sun's mass!

α Crucis is of almost exactly the same brightness as Aldebaran, but it is at double the distance from us, a parallax of only 0″·05 having been found by Gill. Its spectrum (of the "Orion type") indicates, however, that it is a much hotter and brighter body than Aldebaran. Taking its greater distance into account, we may perhaps conclude that it is comparable in size with Aldebaran, and therefore a sun of great size. The star β Crucis, whose stellar magnitude is 1·50, but which has no measurable parallax, must also be a giant sun. Its spectrum is the same as that of α Crucis.

Arcturus and Pollux have similar spectra (K. Pickering). The photometric magnitude of Arcturus is 0·24 and that of Pollux 1·21. The parallax of Arcturus, as found at Yale Observatory, is 0″·026, and that of Pollux 0″·056. From these data it would follow that Arcturus is 11½ times brighter than Pollux. The Sun placed at the distance of Arcturus would shine as a star of about the eighth magnitude, or about 7·7 magnitudes fainter than Arcturus appears to us. This would imply that Arcturus is about 1200 times brighter than the Sun. It must therefore be a sun of gigantic size—probably one of the largest bodies in the universe. The above calculation would make Pollux about 100 times brighter than the Sun.

The bright stars Canopus and Procyon have very similar spectra, but the parallax of Canopus does not exceed 0″·01, while that of Procyon is about 0″·32. Still Canopus is a brighter star, its photometric magnitude being − 0·86, while that of Procyon is + 0·48, a difference of 1·34 magnitudes in favour of Canopus. From these data I find that Canopus is 3500 times brighter than Procyon, and it follows that its volume is 207,000 times the volume of Procyon! If the densities are the same, the masses will be in this ratio, and as the mass of Procyon, as computed from the orbit of its satellite, is about five times the mass of the Sun, we have the mass of Canopus more than that of a million of suns! This is probably the largest sun of which we know anything. Sir David Gill's observations show that the parallax of Canopus does not *exceed* the hundredth of a second as above stated. A smaller parallax would, of course, further increase its size.

The observations of "spectroscopic binary stars" enable us to determine their mass although their distance from us may remain unknown. As their actual orbital velocity can be measured with the spectroscope in miles per second, their distance from the earth is a matter of no importance in the computation of their mass. One of the most remarkable of these interesting objects is the southern variable star known as V Puppis. It is a variable of the Algol type, and also a spectroscopic binary. The plane of the orbit must therefore necessarily pass through the earth, or nearly so, and the mass of the system can be easily computed. The spectroscopic observations show the enormous relative velocity of 380 miles a second! and indicate a mass equal to about 70 times the mass of the Sun. The variation of the star's light shows, according to Dr. A. W. Roberts, that the component stars revolve round each other in actual contact, or nearly so, and that their mean density cannot exceed 1-50th of the Sun's density, or about 0·028 that of water. With such a small density and so large a mass the components must evidently be greatly expanded masses of gas, probably several millions of miles in diameter. The period of revolution is about 34 hours 54 minutes, a wonderfully short period for a pair of suns!

Let us now consider some suns of probably miniature size. The star Lalande 21,185 (7·5 magnitude) in the constellation Ursa Major has a parallax of about 0″·47. At the distance indicated by this comparatively large parallax, the Sun would shine as a star of about 1·7 magnitude, or over 200 times brighter than Lalande's star. Another small star in the same constellation, Lalande 21,258 (8·5 magnitude), has a parallax of 0″·24. This distance would reduce the Sun to about 3·2 magnitude, but it would still be 5·3 magnitudes, or over 130 times brighter than the star.

The small star Argelander-Oeltzen 17,415 of the 9th magnitude has a parallax of 0″·25. The Sun, if placed in the same position, would be over 200 times brighter than the star.

Another small star with a comparatively large parallax is Lacaille 9352. Its magnitude is 7·1, and the parallax about 0″·29. The Sun, if placed at the distance indicated by this parallax, would shine as a star of about 2·7 magnitude. This gives a difference of 4·4 magnitudes, and implies that the Sun is over 50 times brighter than the star. This star has the very large proper motion of 7″ per annum. It is a remarkable fact that the faint stars above mentioned are actually nearer to the earth than Aldebaran, which is one of the brightest stars in the sky.

The famous double star 61 Cygni is also probably of small mass. Taking its parallax at 0″·39, the Sun, if

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placed at the same distance, would be reduced to a star of about 2·1 magnitudes, and as the photometric magnitude of 61 Cygni is about 5·1, we have a difference of 3 magnitudes in favour of the Sun. This makes the Sun nearly 16 times brighter than 61 Cygni, and would indicate that it has about 60 times the mass of the star. The spectrum of 61 Cygni is of the second or solar type, but not exactly similar to that of the Sun.

Some of the faint satellites to bright stars (mentioned in my paper on "Stellar Satellites") must be either bodies of small mass or slight luminosity. Take the case of Burnham's 14th magnitude satellite to Aldebaran. Assuming that its parallax is the same as that of Aldebaran, or about one-tenth of a second, we have the Sun reduced to a star of the 5th magnitude at the same distance. This would make the Sun 9 magnitudes, or about 4000 times brighter than this faint star! It must therefore be either a comparatively small body, or else it must have proceeded a long way on the road to the total extinction of its light. If we suppose the density and surface brilliancy to be similar, the ratio of the masses would be about 25,000 to 1, and this small star would be less than 14,000 miles in diameter. It seems highly improbable that a body so much smaller than the planet Jupiter should continue for long in the sun-like stage. More probably it is a "cooled down sun." If its mass is not miniature, its light is certainly small.

The sun if placed at the distance of Regulus would shine with about the same brilliancy as the 8½ magnitude satellite to that bright star. This satellite has close to it a faint companion satellite of the 13th magnitude. As both are moving through space with Regulus they are evidently physically connected with the bright star and lie at the same distance from the earth. This 13th magnitude star is therefore 4½ magnitudes, or over 60 times fainter than the Sun. The accuracy of the small parallax found for Regulus (0″·022) may perhaps be doubted, but there can be no doubt, owing to the common proper motion of all three stars, that Regulus and the faint satellite are at practically the same distance from the earth. The great difference in their light—nearly 12 magnitudes—indicates that Regulus is about 46,000 times brighter than its faint attendant. There must therefore be an enormous difference either in their size or the luminosity of their surface.

The measures of the double star α Ursæ Majoris show that it is a binary star. There is a difference of at least 9 magnitudes between the components, showing that one is at least 4000 times brighter than the other. Considerable difference in size or great discrepancy in surface brightness is therefore absolutely certain.

The bright star γ Draconis (2½ magnitude) has a faint companion of the 13th magnitude which seems to be travelling with it through space. The difference of 10½ magnitudes between the two implies that one is at least 10,000 times brighter than the other. Their disparity in mass or inequality in surface brightness must therefore be enormous.

Although calculation shows that the companions of Sirius and Procyon are each equal to the Sun in mass, still, as far as luminosity is concerned, they may be considered as miniature, or at least minor, suns. If the Sun were placed at the distance of Sirius it would shine as bright as the Pole Star, whereas the Sirian satellite is only of the 10th magnitude, or nearly 1300 times fainter than the Sun. In the case of Procyon, the Sun placed in the same position would be over 16,000 times brighter than the faint attendant. These small stars are probably "cooled down suns" which are verging towards the total extinction of their light.

Another somewhat similar case is that of the binary companion to the star 40 (o^2) Eridani. This small binary star is of the 9th magnitude, while the primary star is about 4½. As both have a common proper motion through space they are evidently physically connected, and therefore lie at practically the same distance from the earth. Professor Asaph Hall found a parallax of 0″·22 for the brighter star. Assuming this parallax for the binary pair, I find from Burnham's orbit a combined mass equal to 0·71 of the Sun's mass. Placed at the same distance the Sun would shine as a star of 3·28 magnitude, that is 5·72 magnitudes, or 194 times, brighter than the binary, which therefore seems to be another sun, or rather a pair of suns, on the road to extinction.

The globular clusters, composed as they are of such faint stars, suggest the inevitable conclusion that either the components are miniature in size, or else that these wonderful objects lie at a vast distance from the earth. Even an approximate distance has not been found for any of them. If we assume a parallax of $\frac{1}{50}$th to $\frac{1}{100}$th of a second—163 to 326 years' journey for light—the component stars of most of them would be considerably fainter than our Sun would be if placed at the same distance. On this assumption they would be relatively small bodies. On the other hand, if we assume a parallax of $\frac{1}{500}$th to $\frac{1}{1000}$th of a second—from 1600 to 3200 years' light journey—the Sun would be reduced to about the 13½ to 15th magnitude, and this would make the component stars equal to or brighter than the Sun. That each of the stars which compose these clusters is equal to our Sun in size and brightness seems improbable, and perhaps the most likely supposition is that they are comparatively small bodies, and are not so far from the earth as is sometimes supposed.

Ceylon Pearl Oyster Fisheries.

Professor Herdman's Report to the Colonial Government.

IN 1801 the Island of Ceylon became definitively a British possession, and with the removal of Dutch power there passed into English hands the control and the proceeds of the "pearl oyster" fisheries. Since the occupation of the Island its pearl banks have, it is computed, brought over one million pounds sterling into the treasury chest of the Government.

Although the aggregate amount derived from the Ceylon fisheries is suggestive of a prosperous maintenance of the native industry, in reality the situation has long afforded ground for disturbing conclusions. In the year 1891 there was an extraordinarily abundant oyster yield, the estimated revenue being placed at one million rupees, whereas ensuing periods have demonstrated but a dismal tale of fishery failures. There was, however, a good fishery last year (1903). Theories and speculations have been put forth from time to time regarding the phenomena of these strange oyster disappearances, but comparatively little which might tend to throw real light upon the question has resulted from the discussions.

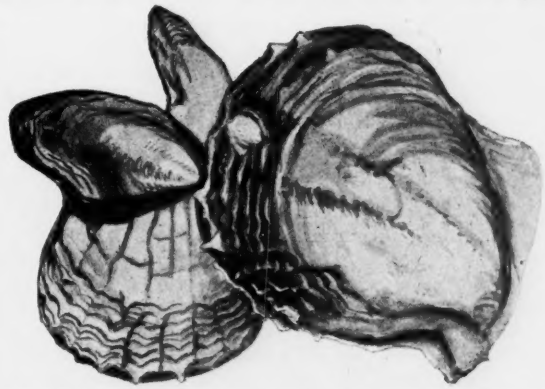
In such circumstances and mindful of the probable recurrence of conditions likely to profoundly modify or even jeopardise the pearl fishery, the Colonial Government determined in 1900 to seek outside and expert aid with the view of elucidating the scientific and economic

problems that were involved, and accordingly commissioned Professor W. A. Herdman, F.R.S., of the Natural History Department of the University of Liverpool, to proceed to Ceylon, in company with a qualified scientific assistant, to commence a survey and carry out a series of investigations and experiments. The steamship *Lady Havelock* was placed by the Ceylon authorities at Professor Herdman's disposal for the work of examining the biological surroundings of the pearl oyster banks, and during two successive cruises of three or four weeks each he inspected out at sea all the principal banks, established lines of dredging and trawling, and made observations across, around, and between the banks in order to ascertain the conditions that satisfy an oyster "paar," the term applied to the varied rocky strata (as opposed to shifting sandy layers) beneath the water which constitute the habitat of the animal. In all

Native Divers employed by Prof. Herdman.

these operations the Professor found an able coadjutor in Mr. James Hornell, his assistant, who, it may be added, is still in Ceylon furthering the enquiry. Enough, however, has already been accomplished to permit the issue of a detailed report embracing a description of the banks, and a record of the studies that were made on the life-history of the pearl oyster itself. The accompanying illustrations we are privileged to reproduce from this Report.

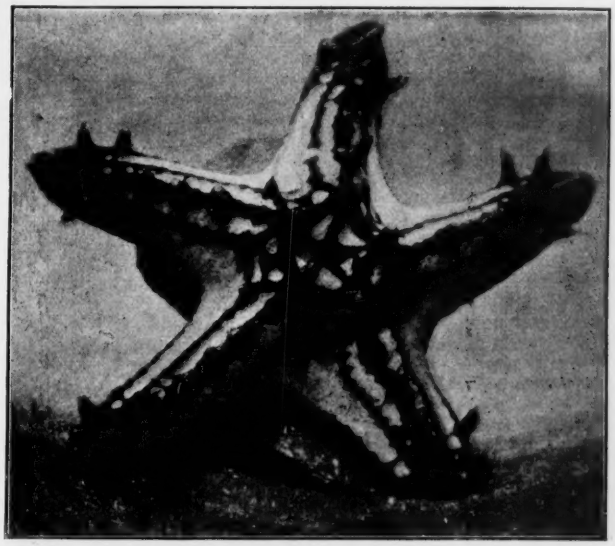
Much virtue often attaches to a name, but in the case of the so-called pearl oyster we have to disabuse our mind of any lingering belief that it is a true oyster, since, as a matter of fact, the animal belongs to the family Aviculidæ, and is therefore more nearly related to the Mussels (*Mytilus*) than to the Oysters (*Ostræa*) of British seas. One character in particular marks it off from *Ostræa*, namely, the ownership of a "byssus," or bundle of tough threads, by means of which it can tag itself on to rocks or other adjacent objects, as do its congeners, the Mussels. The species has favoured Ceylon waters, or, more strictly, the shores of the Gulf of Manaar on the north-west, in countless generations from remote antiquity, hence, long prior to European rule; while the praises of the "orient" pearl have been uniformly ex-



A Bunch of Oysters from the sea bottom. Four generations are seen. The largest is $3\frac{1}{2}$ years old, and the smallest, attached to the large shell, is about a month old.

tolled in many a classical allusion. All over the district the pearl oyster of the banks is the same animal, a decision that was quickly arrived at by Professor Herdman; furthermore, the method of fishery now pursued, even to the manning of the divers' boats and the custom of the cessation of diving at noon, is a continuation of ancient practice.

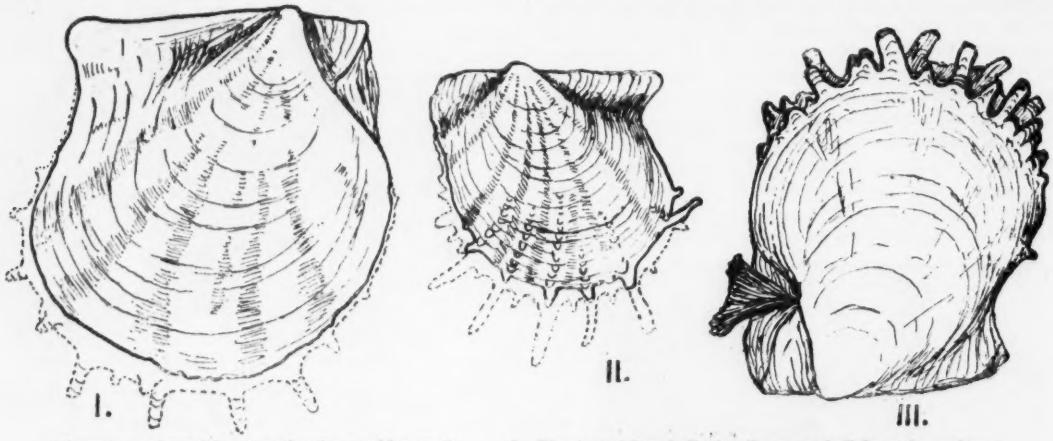
Of the causes which lead up to the disappearance of the oyster population—sometimes in hundreds of thousands—and the devastation of the banks, the Commissioner has much to say that is of interest. Influences such as oceanic currents, monsoon storms, and shifting sands have each their play; added to which, in common with other classes of marine denizens, the pearl oyster has its enemies. Boring sponges may destroy the shell, and boring molluscs suck out the animal. Then there are the star-fishes and carnivorous fishes to reckon with. But, as Professor Herdman remarks, compensation arises



One of the enemies of the Pearl Oyster. A starfish lying on a large oyster. Half natural size.

in these matters; for instance, one foe, a Plectognathid fish, which possibly devours very many oysters, at the same time receives and passes on the parasite which results in the production of pearls in others.

The life-cycle of the pearl oyster is described from the egg onwards to the adult animal, and the story unfolded is one of singular interest. *Margaritifera vulgaris* was, in fact, most seriously studied; partly in miniature experimental tanks, with the first aid of the microscope; again, in the hauls of the tow-net; and by means of diving trials at the sea depths, where, it may be noted, the oyster occurs on the rocky bottom in 5 to 10 fathoms of water. In the vicinity of the Manaar Gulf pearl banks this element is so clear that under the rays of a high sun the depths are brilliantly illuminated. A passing shadow will cause the animals to immediately snap-to their valves.



Three transplanted Oysters showing rapid growth. I. The dotted line indicates the new shell formed—23 days. II. New shell formed in 21 days. III. Oyster showing a month's growth—Natural size.

Valuation sample of Pearl Oysters in course of delivery from the inspection boats.

As regards pearl-formation, some pearls or pearly excrescences on the interior of the shell were detected as being due to the irritation caused by boring sponges and burrowing worms, but the minute grains of sand or other internal particles popularly supposed to form the nuclei of pearls are considered only to do so under exceptional circumstances. The majority of the best gems, on the contrary, are caused by the stimulation of a parasitic worm which becomes encased and dies. And this parasite is the Cestode larval *Tetrarhynchus*. Professor Herdman purposes dealing with this aspect of the question of pearl-formation at greater length later on.

Finally, there is one general conclusion that is reached in this opportune and admirable Report, and it is all-important. We are told that there is no reason for any feeling of despondency in regard to the future of the pearl fisheries of Ceylon if they are treated scientifically. Adult oysters are plentiful on some of the paars and seem for the most part healthy and vigorous; while young oysters in their first year and masses of minute spat just deposited are very abundant in many places. "The material exists, ready for man's operations."

[According to a *Times* telegram from Colombo on December 9th, 1903, Captain Legge, Master Attendant, on his return from inspecting the pearl banks, has decided against the proposed fishery this year. The next fishery will be in February, 1905.]

Astronomical Notes.

Sir W. Ramsay on New Gases and Radium.

SIR WILLIAM RAMSAY addressed the British Astronomical Association on December 30, on the subject of "Stars and Atoms." In the earlier part of his lecture he recounted the history of the discovery of the new gases, Argon, Helium, Neon, Xenon, and Krypton, exhibiting representations of their spectra, and explaining their places in the periodic series. He dwelt specially on the last-named gas with reference to its connection with Auroræ, and showed that the principal line in the auroral spectrum was the chief line of Krypton. Passing then to the discovery of radium, he described the properties of this element, including the three kinds of rays that it gives off, and suggested that we might find an analogy to the constitution of the molecule of this, the densest of all known elements, if we imagined a closely aggregated solar system, or better still, a stellar cluster, in which the collisions were frequent, or at least the perturbations often excessive, leading to the continual loss by the system of members whose velocities thus attained a greater than the critical. Such instability, he suggested, would be only perceptible in the case of unusually dense elements.

Solar Activity and Terrestrial Magnetism.

The principal subject of the papers at the Royal Astronomical Society, on January 8, 1904, related to the connection between solar activity and terrestrial magnetism. Mr. William Ellis pointed out an annual inequality in the frequency of auroræ as observed in these latitudes, corresponding to that established in the frequency of magnetic disturbances. Mr. Maunder drew attention to the two great periods of exceptional solar quiescence, and suggested a connection with the secular change of magnetic declination. Mr. Maunder examined the details of the nineteen greatest magnetic storms, since 1875, and the nineteen greatest sun spots, and suggested that the action from disturbed regions on the Sun might have a maximum effect in a given direction, and that this would explain quantitative discrepancies between certain sunspots and the magnetic storms which appeared to synchronise with them.

Stellar Magnitude of the Sun.

Mr. Charles Fabry, at the meeting of the Paris Academie des Sciences on December 28, 1903, communicated the result of his photometric determination of the stellar magnitude of the Sun. On December 7 he had reported that he found the Sun's light to be 100,000 times more intense than that produced by a decimal candle at a distance of one metre. A similar investigation, with the star Vega as the subject, gave the star's light as equal to that of a decimal candle at 780 metres. The stellar magnitude of Vega being taken as 0·2, that of the Sun was inferred to be −26·7.

Double Spiral Structure in Hercules.

Professor J. M. Schaeberle, in the *Astronomical Journal*, No. 552, announces his discovery of a double spiral structure in the great cluster in Hercules, the more pronounced spiral being clockwise, the other being counter-clockwise; the clockwise spiral being formed by the inner streams of *outgoing* matter, the seeming counter-clockwise spiral by that part of each stream which contains *returning* matter. The plane of the spiral is not normal to the line of sight. A precisely similar structure on a much larger scale appears to exist in the stars and nebulosity surrounding Gamma Cassiopeiæ.

Botanical Notes.

A New Rubber Plant.

ANOTHER plant containing rubber is now arousing considerable interest in Colorado, according to Mr. T. D. A. Cockerell's paper in the *Bulletin of the Colorado College Museum*, No. 1, where a description of the plant is given under the name of *Picradenia floribunda utilis*. It is a native plant, belonging to a North American genus of Compositæ, and resembles in appearance the French marigold genus (*Tagetes*), to which it is allied. Unlike most of the previously known rubber plants, this is a rather dwarf herb, and the rubber is obtained, not from a woody stem, but from the roots, where it is found in large quantities.

A New Genus.

A curious new genus is described in the Japanese *Botanical Magazine* for September, 1903, to which the name *Miyoshia* has been given. The only species at present known is a small, saprophytic, leafless plant, quite destitute of chlorophyll. It was found in a forest in the province of Mino, Japan. The author considers the genus to be closely related to *Aletris* in Liliaceæ, but as he cannot fit it into any already established order he has put it into a new one, which he has called Miyoshiaceæ. The tubeless perianth and semi-inferior ovary suggest some Hæmodoraceæ.

Root Formation.

In the *Osterreichishe Botanische Zeitschrift* for December, 1903, Leopold Ritter von Portheim records his observations on root-formation on the cotyledons of *Phaseolus vulgaris*. Experiments with beans carried on for five years before 1901 were unsuccessful, but in that year the desired results were obtained in eleven cases. The plants were grown in the dark in distilled water or in a nutritive solution free from lime. Roots developed, sometimes one, sometimes two or three, on the cotyledons near the attachment to the axis. It was also found that roots, and less frequently shoots, would form on cotyledons separated from the axis, but it was not quite clear whether the shoots were auxiliary or not, in spite of the careful separation of the cotyledons.

British Ornithological Notes.

THE column in KNOWLEDGE hitherto devoted to British Ornithological Notes, and conducted by Mr. Harry F. Witherby, will, we regret to say, be now discontinued. Mr. Witherby wishes us to convey his sincere regrets to our readers that this course has been found necessary, and that no longer notice could be given.

REVIEWS OF BOOKS.

"The Evolution of Earth Structure, with a theory of geomorphic changes." By T. Mellard Reade, F.G.S., F.R.I.B.A., A.M.I.C.E. Pp. xvi. + 342. (London: Longmans, Green, and Co., 1903; price 21s. net.) Mr. Mellard Reade, with his long experience as an architect and engineer, has never lost an opportunity of applying physical principles to the explanation of the structure of the earth. His well known thermal theory of the origin of mountain ranges is discussed in our geological text-books; and he has been a consistent believer in the adequacy of subsidence and elevation in explaining the main problems of our Pleistocene deposits. In the present work, he has not attempted a continuous argument, but has brought together a number of papers and experimental observations which bear upon the development of the present surface of the earth. Mr. Reade does not shrink from controversy, but his methods of inquiry are always sympathetic. He relies (p. 33) on fluctuations of temperature in the earth's crust in accounting for surface-movements, differences of specific gravity, and local increases or decreases of volume, being thereby set up in the outer layers. A diagram (plate 1) illustrates his views on the formation of laccolites and batholites, by the expansion and melting of portions of the igneous shell which underlies the sedimentary series. We do not understand the "5956 miles" which are marked on this plate near the centre of the earth, and we are tempted to suspect the whole, on account of its obvious simplification. The serious reader of this book will come to it, however, well prepared, and will probably accept Mr. Osmond Fisher's permanently liquid layer, quite as readily as Mr. Reade's "semi-plastic underlying shell." Having shown how the vertical uplift of continental platforms, and the vertical falling in of oceanic basins, may be brought about, the author considers the local wrinklings in these areas, such as have produced our mountain chains. He attributes the tangential creep (p. 45) to the transference of material by denudation from one place to another, promoting subsidence, heating of the lower layers, and lateral expansion, with consequent crumpling of the strata. But Mr. Reade urges, and we think very wisely, that the alleged permanence of continents and oceans does not rest on geological evidence, when we extend our view over a sufficient lapse of time. He emphasises the occurrence of considerable and even mountainous irregularities in the floors of our present oceans, and denies that the edge of the continental plateaux represents any marked break between continental and oceanic forms (p. 103). The scarp so often noticed is aptly compared to the outer end of an artificial embankment formed by tipping, the *débris* from the land being largely responsible for what are often styled "submerged platforms."

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The experimental models, by which mountain-structure is made to arise in circular circumscribed areas, are of wide interest (pp. 131-215), and lead to some criticism of the views of Suess on the potency of differential subsidence to produce the oceanic depths and the high continental masses.

Chapter XIX., on Slaty-Cleavage, descends somewhat from geomorphology to petrology; the interesting details have been already published by the Liverpool Geological Society. The volume also contains a paper on the denudation of America, in which the relations of continents and oceans are again discussed; and a final and lucid statement of the case against those who have asserted the permanence of these larger features of our globe.

The geological reader and the librarian will not consider the price of Mr. Reade's book high, when once they have turned it over, and have noted the numerous original illustrations, which in themselves give it a permanent value.

Galileo: His Life and Work, by J. J. Fahie. (London: John Murray, Albemarle Street, W., 1903; 16s. net.) Mr. Fahie has succeeded in giving a very life-like and attractive picture of the great philosopher. His restless energy of investigation, his keenness of observation, his affection and generosity to his relatives and friends (many of whom were most undeserving), and the biting wit with which he attacked his enemies are brought vividly before us. The last named quality was his ruin, and, far more than any novelty or heresy in the doctrines he taught, brought upon him the bitter persecutions from which he suffered. His real crime was that he made his opponents a laughing-stock, and Pope Urban VIII. believed that he too had been "made game of." He had given Galileo an argument against the proof which Galileo considered the most cogent in establishing the motion of the earth round the sun. Galileo placed that argument in the mouth of Simplicio, the representative of the Ptolemaic philosophy in the great "Dialogue," and the Pope regarded this as equivalent to saying that he was a "simpleton." Curiously enough this same irrefragable proof—the argument from the tides—is untenable, so that the Pope's objection has been justified by the result, though his mode of reasoning was unscientific.

Galileo's attitude of mind towards science was quite different from that of his contemporaries. As a result of this, his life was one of brilliant scientific triumphs, but also of unceasing conflict and bitter suffering, relieved, however, until the last eight years of his life, by the touching and romantic devotion of his noble-hearted daughter, Virginia. His is a heroic figure, and it as a hero that Mr. Fahie has treated him; the one fault to be found with his portrayal of him being that, like the Aristotelians of Galileo's day, he will not allow that there can be any spots on his sun, for he supports Galileo where he least deserves support, namely in his refusal to allow any merit to rival and independent workers in the same fields, such as Lippershay, Scheiner, and Marius.

The Saltness of the Dead Sea.

Two causes, says Mr. William Ackroyd, in the report of the Palestine Exploration Fund, have been assigned to account for the saltness of the Dead Sea. The first of these is the accumulation of chlorides, which solvent denudation derives from the rocks of the Holy Land. The second explanation is that an arm of the Red Sea was cut off by the rising of Palestine in prehistoric ages, and in either or both cases the saltness would have been intensified by evaporation. There remains, however, to be taken into consideration a third cause—the atmospheric transportation of salt from the Mediterranean. This may not improbably be a more potent factor than either of the other two causes of the Dead Sea's saltness. The salt which the winds carry inland from the sea falls in rain and is carried back again to the sea; but in the case of an inland lake without outlet it remains for evaporation, so much so that in the case of a Pennine reservoir water equally salt with that of the Dead Sea would be produced by this means in a fraction of the time usually assigned to the Pleistocene Age. Taking specimens of the rocks on which Jerusalem is built as samples of the Palestine rocks, they are found to be limestones of various compositions, and with the one exception of Kakule limestone, which contains 0·025 per cent. of chlorine, or 0·041 of common salt, the chlorine contained in these rocks approximates to the general average of that found in the limestones of other countries of 0·01 per cent. This percentage would be quite inadequate to account for the salt in the Dead Sea, and the salt yielded to rivers by denudation is not a ninety-ninth part of that which has been supplied by rain water. Nor would the saltness of the Dead Sea be fully accounted for if a marine area had been cut off during the rising of the land, as the initial saltness thus acquired would only be about a fourth of that subsequently attained to; and, moreover, in this condition of saturation it has been for an unknown length of time continually precipitating its excess of salt. The intensity of meteorological conditions in the past geological history of Palestine have been much more severe than those now obtaining, and the atmospheric transportation of salt would be correspondingly greater. Some of the salt then accumulated has been left by the dwindling waters of the Dead Sea in areas to the north and south, notably in Jebel Usdum, and the highly brackish rivulets which come from these neighbourhoods now are but contributing again what long ago came from more distant sources.

The Nebulosities round γ Cygni.

By Dr. MAX WOLF, F.R.A.S.

I DISCOVERED these large nebulous masses in 1891, and on several occasions have published photographs of them. Some two and a half years ago I was fortunate enough to get a fairly good picture of them with my sixteen inches Brashear lens, which I hope may prove of interest to the readers of "KNOWLEDGE & SCIENTIFIC NEWS." The accompanying plate has been made from a contact print from the original photograph, which was exposed for nearly seven hours, on the nights of July 16 and 17, 1901.

The bright star involved in nebulosity in the centre of the plate is γ Cygni. The star, α Cygni, is not included in the plate, but would lie a little outside it, at the left upper corner. The nebulous stream running diagonally across the plate, in the line joining γ Cygni and α Cygni is very distinctly shown. But the most striking feature of this region is furnished by the broken nebulosities near the centre of the plate. The contrast, too, afforded by the crowds of stars and the nebulous masses is very remarkable. In some places all are mixed together, bright stars, small stars, and nebulosity; whilst in others the intervals between the stars are entirely free from nebulosity. Very striking, too, are the irregular dark holes in the nebulosity to the west of γ Cygni, and the clouds to the east, and north-west of that star. A curious straight line of stars crosses the plate north of the centre.

The scale of the plate is 32 millimetres to one degree of arc.

NORTH.

EAST.

WEST.

THE NEBULOSITIES ROUND γ CYGNI.

From a photograph taken by Dr. Max Wolf, at Heidelberg, on July 16th and 17th, 1901.

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The Ancestry of the Elephants.

By A. SMITH WOODWARD, LL.D., F.R.S.

LONG before the ancestry of the horses and camels had been discovered in North America, some of the immediate fore-runners of the elephants had been recognised and discussed in the Old World. The discoveries of Falconer and Cautley in India, of Falconer, Gaudry, and others in Europe, had made it evident that the elephant was derived by gradual stages from a more normal kind of quadruped. These gradations, however, could only be traced back as far as the Middle Miocene period, and no known animal of earlier date could be claimed as ancestral to the series. Lower Miocene and Eocene quadrupeds continued to be discovered in abundance, but never any trace of an elephantoid creature. The natural conclusion therefore was that the race of elephant-like animals only reached Europe and Asia in the early part of the Miocene period by migration from some other region in which the early stages of their tribal history were passed. It eventually became probable that the African continent would yield these ancestors, and students of extinct animals began to look with confidence to that part of the world. Their expectations have not been disappointed; for the recently-published researches of Dr. Charles W. Andrews on early Tertiary Mammalia from Egypt* have furnished precisely the missing links that were desired. The evolution of the elephant-tribe is now almost as well known as that of the horses, camels, and their allies; and Africa is proved to have been its ancestral home.

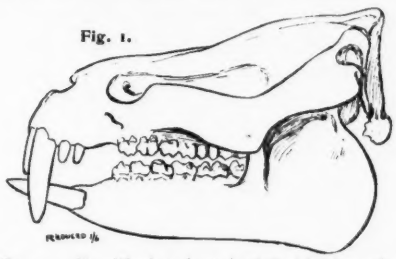


FIG. 1.—*Moeritherium byonsi*; left side-view of skull, upper view of mandible (A), and diagrammatic section of last molar tooth (B).—Middle Eocene; Egypt.

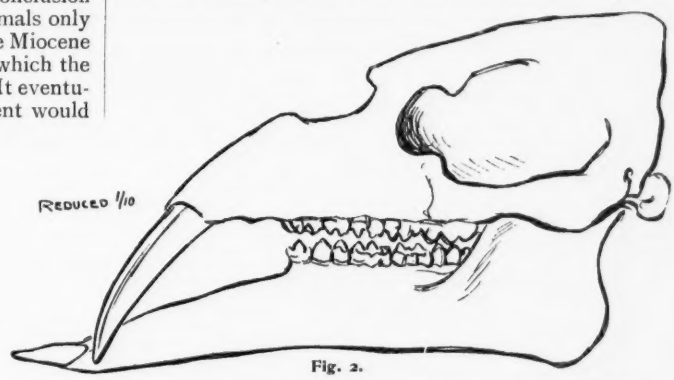


FIG. 2.—*Palæomastodon beadnelli*; left side-view of skull, upper view of mandible (A), and diagrammatic section of last molar tooth (B.)—Upper Eocene; Egypt.

The body of the elephant has changed very little during its long geological history. It has always retained the simple limbs with five toes and unaltered wrist and ankle. It has merely become a little shortened in proportion to its height, while the supporting limbs have grown in stoutness as the successive representatives of the tribe have increased in size and weight. In fact, it is permissible to describe the massive frame of a modern elephant as essentially an overgrown copy of the skeleton of a herbivorous quadruped of the early Eocene period.

All the features which make elephants unique among Mammalia are therefore to be observed in the head and neck. The story of their evolution is concerned mainly with the gradual enlargement of their tusks and complicated grinding teeth, and with the eventual growth of a peculiarly flexible, boneless, and prehensile prolongation of the face, which is commonly known as the proboscis or trunk. It is, in short, the story of a race which once fed in a normal manner on succulent weeds, browsing like any other herbivore, but afterwards began to subsist on drier or harder vegetation, and at the same time lost the power of reaching the ground with its mouth, depending for help on a modification of the snout which is elsewhere unknown.

The oldest recognised member of this race is the small *Moeritherium* (fig. 1) from the Middle Eocene of Egypt. It comprises species not much larger than the existing tapirs, and they possess a neck sufficiently long and flexible to have allowed them to browse in the ordinary way. The skull of *Moeritherium* shows that it did not support more than a rudimentary proboscis, but there are certain features in its structure which suggest a tendency towards arrangements now specially characteristic of the elephants proper. The teeth are disposed in a long series, and are nearly as numerous as in any of the early quadrupeds. In the upper jaw there are the usual three pairs of front cutting teeth or incisors, but the second pair is much larger than the others, and forms conspicuous downwardly-curved tusks. Small canines, or corner teeth, are also present; and there are six grinding teeth on either side (three pre-molars and three molars), most of them bearing two cross-ridges, the hindermost also with a third small posterior ridge (fig. 1B). The lower jaw (fig. 1A) likewise has six grinding teeth, of which the molars closely resemble those of the upper jaw; but canine teeth are absent, and there are only two pairs of incisors, the outer pair being much the larger. The jaws are narrow, but there is no conspicuous prolongation of the chin (or mandibular symphysis).

The next genus, from the Upper Eocene of Egypt, is much more clearly elephant-like. It is named *Palæomastodon* (fig. 2), and comprises species somewhat more than twice as large as any of the earlier kinds of *Moeritherium*. A peculiar elongation of the skull and a long, spout-shaped growth of the bone of the chin (mandibular symphysis) are now very noticeable, and all the incisor teeth except one pair have disappeared above and below.

* "On the Evolution of the Proboscidea," Phil. Trans., 1903B, pp. 99-118.

The surviving upper incisors are rather large tusks, and have lost all the enamel except a narrow band on one face—exactly like the front teeth of a gnawing animal (Rodent). The lower incisors are at the end of the chin far in front of the upper tusks, and they are still more like the incisors of a rodent (fig. 2A). They have a band of enamel on their lower face, and they are worn to a chisel-shaped edge by some opposing hard substance—

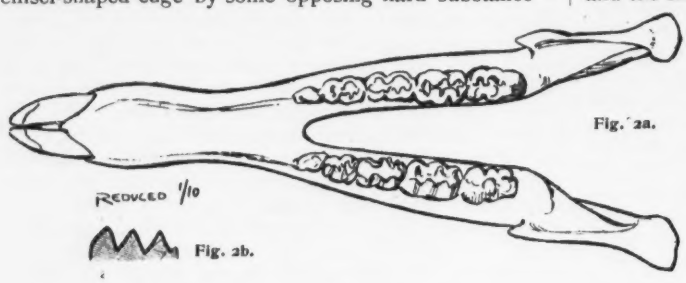


Fig. 2a.

Fig. 2b.

perhaps a pad on the palate. The grinding teeth of the upper jaw are as numerous as in *Moeritherium*, and those of the lower jaw are only reduced by the loss of another front pre-molar. The three molars, however, are relatively larger and more complicated than in the earlier genus, each bearing three cross-ridges, the hindermost also with a rudimentary fourth ridge (fig. 2B).

ones take their place; and these teeth exhibit greater complication than before, the posterior molar at least bearing four cross-ridges, with a rudiment of a fifth ridge (fig. 3B).

There is not much doubt that, with so remarkably elongated a head, *Tetrabelodon* would be able to browse on or near the ground, notwithstanding the length of its legs and the shortness of its neck. However, the shape of the skull shows that, even if the animal did not need a proboscis, the arrangement of the soft parts of its face and nose must have closely resembled this prehensile organ in a modern elephant. The outline of the head is, indeed, fancifully given in the accompanying fig. 6; and from this it is evident that the only hindrance to the use of the snout as a typical proboscis is the immensely elongated bony chin which underlies it.

Towards the close of the Miocene period many of the "mastodons," as these animals

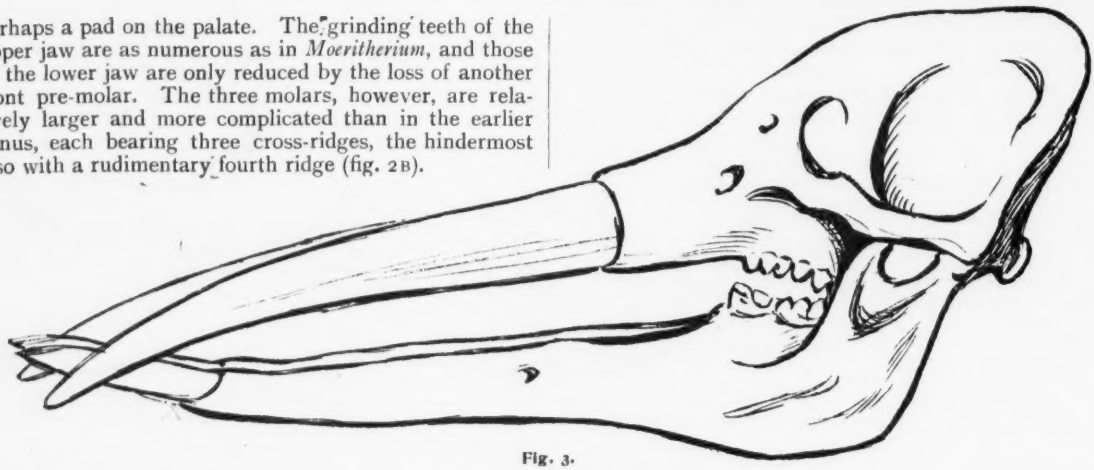


Fig. 3.

FIG. 3.—*Tetrabelodon angustidens*; left side-view of skull, upper view of mandible (A) and diagrammatic section of last molar tooth (B).—Middle Miocene; Europe.

The elephant-like quadrupeds continued to live in Africa from the Eocene period to the present day, but, probably through some re-arrangement of land and sea, they also wandered into Europe in the early part of the Miocene period, and soon afterwards penetrated even to the extreme eastern limits of Asia. The European and Indian members of the race during these later periods are indeed better known than those from Africa itself, and they must be referred to for information concerning the Miocene and Pliocene developments.

In the Middle Miocene, as shown by *Tetrabelodon angustidens* (fig. 3), the hinder part of the skull becomes short and deep, the upper tusks and their sockets are

are generally termed, actually lost their bony chin by the shortening of the lower jaw. The soft snout being then destitute of support of any kind, must have begun to droop downwards; and there is thus no difficulty in understanding how it eventually became the essential feature of the modern elephants.

Some of the short-chinned species which form the genus

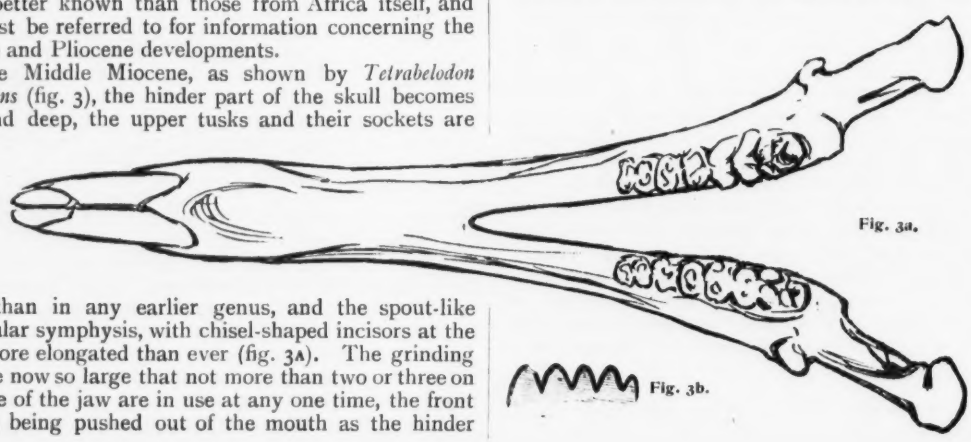


Fig. 3a.

Fig. 3b.

longer than in any earlier genus, and the spout-like mandibular symphysis, with chisel-shaped incisors at the tip, is more elongated than ever (fig. 3A). The grinding teeth are now so large that not more than two or three on each side of the jaw are in use at any one time, the front grinders being pushed out of the mouth as the hinder

Mastodon of the Upper Miocene and Lower Pliocene periods in the Old World, of the Pliocene and Pleistocene periods in America, are provided with grinding teeth scarcely more complicated than those of the earlier *Tetrabelodon*. Their upper tusks also differ only from those of the latter in having lost the band of enamel

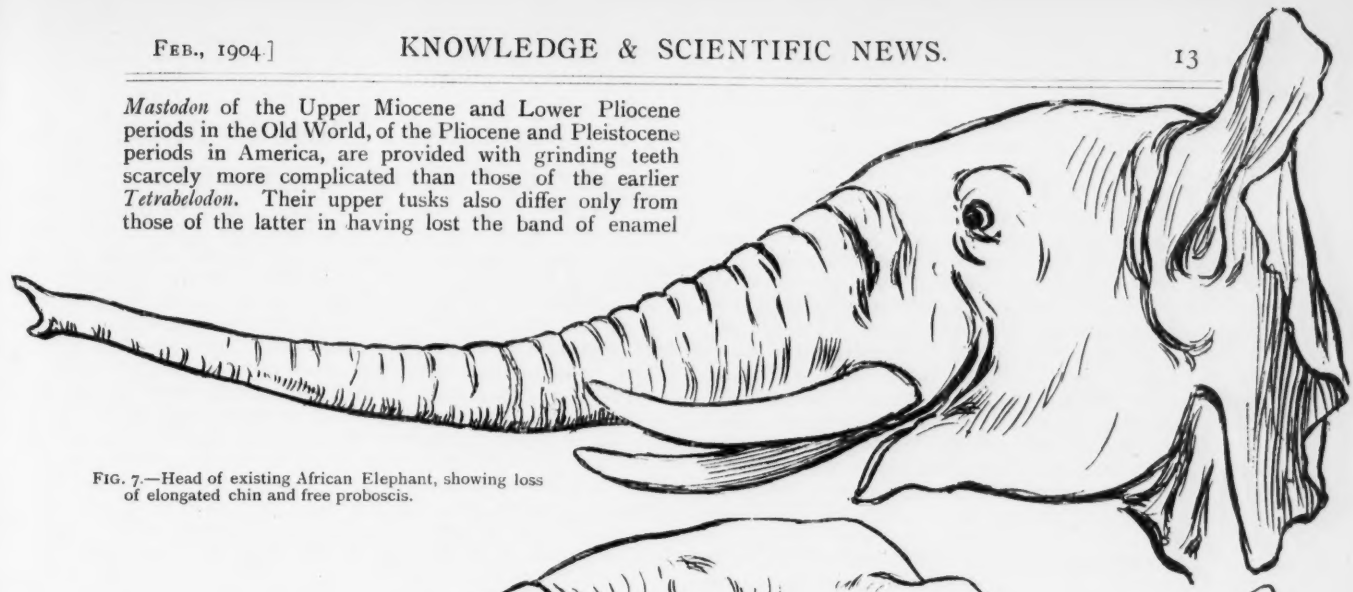


FIG. 7.—Head of existing African Elephant, showing loss of elongated chin and free proboscis.

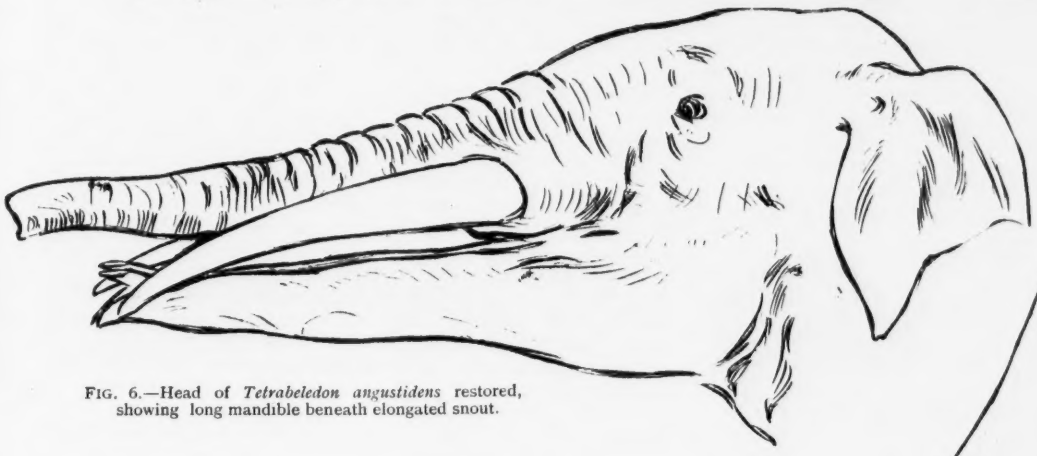


FIG. 6.—Head of *Tetrabeledon angustidens* restored, showing long mandible beneath elongated snout.

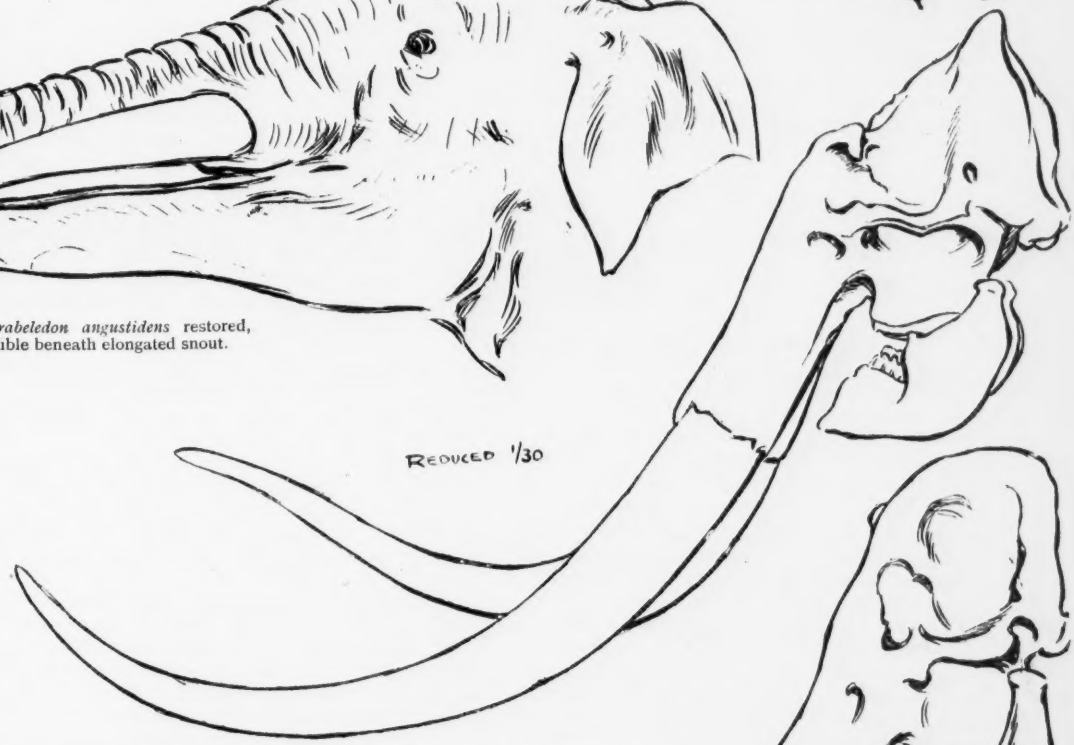


FIG. 5.—*Elephas primigenius*; left side-view of skull, upper view of mandible (A), and diagrammatic section of molar tooth (B.)—Pleistocene: Northern Hemisphere.

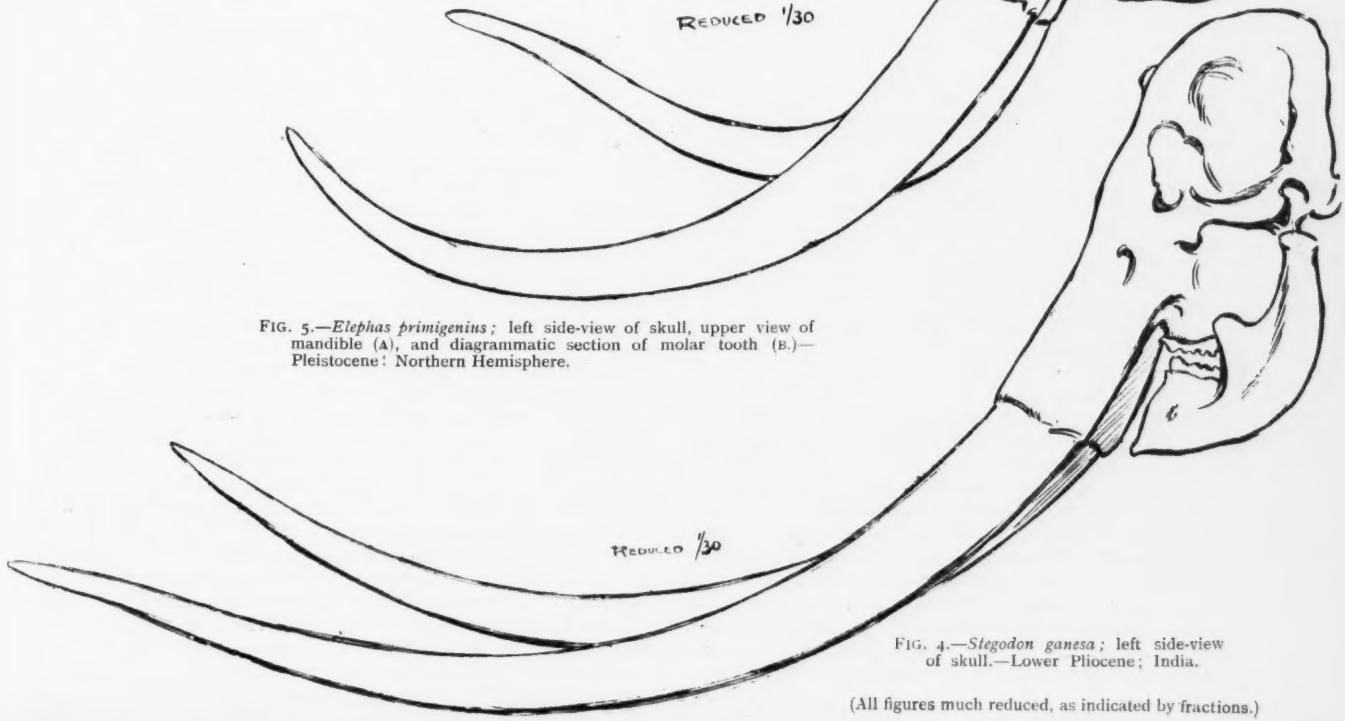


FIG. 4.—*Stegodon ganesa*; left side-view of skull.—Lower Pliocene; India.

(All figures much reduced, as indicated by fractions.)

outside the ivory. Their lower tusks, however, are merely functionless rudiments, often lost when the animals are full grown.

At the same time it is interesting to observe, that as soon as the shortened chin and unsupported face had become characteristic of the "mastodons," true elephants with deep and ridged grinding teeth made their appearance at least in the Indian region, and quickly spread over all the Old World. The tusks of some species (fig. 4) now grew to immense size. The cross-ridges of the grinding teeth (fig. 5B) also became more numerous, and so much deepened and compressed that they might rather be described as plates; while the inconvenient crevices between them were filled for the first time with a third kind of tooth-substance, which is rather soft, termed cement. In the Lower Pliocene *Stegodon*, as the earliest true elephant is named, large grinding teeth, consisting of alternating cross-bands of hard and soft tooth-substance, were thus fully fashioned.

The later elephants and those of the present day only differ from each other in minor characters, and in the degree of compression or multiplication of the plates of their grinding teeth. The maximum complexity of tooth-

Fig. 5a.

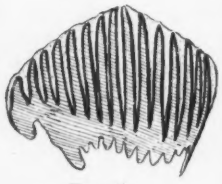


Fig. 5b.

structure is reached in some of the hairy elephants, or mammoths (fig. 5) of the Pleistocene period, which ranged far north, even within the Arctic Circle, and may often have been compelled to feed on specially hard and dry vegetation. Their grinders (fig. 5B) are much deepened, capable of withstanding many years of wear in the mouth; and the numerous plates of which the posterior grinders are composed would hardly be recognised as simple tooth-ridges if all the initial stages in their evolution now described were not forthcoming.

The general conclusion, therefore, is that the history of the elephant is analogous to that of the other tribes of hoofed animals which culminated in the horses and the cattle. They have grown from mere creatures of the marshes to roam over the plains, or through forests, and have at the same time gradually acquired deeper and more effective grinding teeth. For some inexplicable reason, the lengthening of their legs with a concomitant shortening of their neck, necessitated a unique elongation of their face and chin to reach the ground for browsing. When this strange makeshift had reached its maximum degree, the chin suddenly shrivelled, leaving the flexible, toothless face without any support. By stages which we cannot discover, because they concern only soft parts which are never fossilised, this flexible face became the wonderful prehensile proboscis of the elephants as we know them to-day.

The Latest Discovery Concerning Cancer.

By J. T. CUNNINGHAM, M.A., F.Z.S.

WHENEVER a startling discovery is made in science the hope immediately arises that it may be applied to the cure of the most dreaded of human diseases. X-rays have been tried, and now physicians and patients are in despair because radium cannot be obtained with sufficient facility. But even if radio-activity is found to be capable of checking the malignant progress of cancerous growths, it is not likely to be more than a refined method of cauterisation, a merciful substitute for the surgeon's knife. No radical improvement in the treatment of the disease is probable until we know more of its nature and causes; still less is it possible without such knowledge to devise methods of prevention. The brilliant discoveries of recent years have shown that many of the most dangerous diseases are caused by infection, by the introduction into the human body of infinitesimal organisms of an animal or vegetable nature. Typhoid and tuberculosis, for example, are due to vegetable germs, malaria to minute active organisms belonging to the animal kingdom, and in the latter case the disease is only communicated by means of inoculation carried out by mosquitoes.

Numerous attempts have been made to prove that cancer is also a germ disease, but the latest researches tend to show that this view is erroneous. There is a certain amount of evidence that cancer may be to a certain degree infectious, but nothing to prove that the contagion is caused by the transmission of a living germ as in typhoid fever or malaria. The peculiarity of cancer among diseases is that it consists in the rebellion and malignant behaviour of certain parts of the body itself, not in the attacks of foreign enemies. Cancer in fact is a state of civil war in the body, a reign of terror produced by outbreaks of murderous fury on the part of licentious revolutionists at one or more localities.

The body is a complicated organisation of which the ultimate units are microscopic cells, each cell being a speck of living substance containing a central denser particle called the nucleus. The cells are of different shapes and sizes, and are united in various layers and masses which constitute the tissues, such as the muscular tissue, the bones, the brain and nerves, &c. Growth is due to cell-division, one cell dividing into two, and each of these two growing till it is again as large as the mother-cell, from which it was produced. The fertilised egg from which the body of any animal is developed is a single cell, and the development commences by the division of this cell into two, which divide into four and so on.

In this process of cell-division is manifested to the microscopist a regular series of changes in the nucleus. In its resting state the nucleus is a spherical structure containing a network of delicate threads. In division the spherical outline disappears and the network acquires the form of a convoluted continuous thread. This thread divides into a number of separate V-shaped loops, which are arranged on the finer lines of a spindle-shaped figure. Each loop divides along its length into two loops, and one half of each loop passes to one end of the spindle, the other to the other. This is the central event in cell-division, by which one group of nuclear loops forms two groups, and each of the latter forms a daughter-nucleus.

Now it is a curious fact that the number of these nuclear threads which appear at each cell-division is

constant in the same species of animal throughout life. The number may be 8, or 12, or 20, or 40, or some other number, but in the human body or that of any other animal the number is the same in each cell-division. To this statement, however, there is an exception. In the divisions which lead to the formation of reproductive cells, eggs or sperms, only half the usual number of loops is formed, and the division of these cells is of a peculiar type. The V-shaped chromosomes are replaced by loops and bends and rings, and these, also, range themselves in a different way. This is one of the most curious facts in microscopical science. Fertilisation consists in the complete union of the nuclei of two reproductive cells, and if the same number of nuclear loops were always formed, this number would be doubled in each generation, so that if we began with two we should go on to an infinite number. But as each reproductive cell has only half the proper number, the fertilised egg formed of two cells again has the proper number for the species.

Professor Farmer, of the Royal College of Science, with his colleagues, Mr. J. E. S. Moore and Mr. C. E.

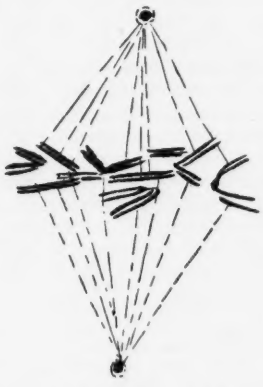


Fig. 1. — Diagram a somatic division showing the split chromosomes, the halves of which form the daughter nuclei. The full number of the chromosomes is not shown.

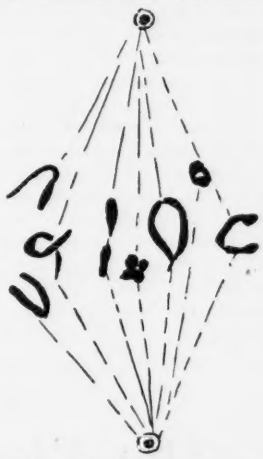


Fig. 2.—Diagram of a heterotype division showing the characteristic rings and loops which split transversely to form the daughter elements. As in the preceding figure, the full number of chromosomes is not shown.

[Reproduced, by permission, from *The British Medical Journal*].

Walker, has made the remarkable discovery, which has just been communicated to the Royal and the Linnæan Societies, that these peculiarities in the division of reproductive cells occur also in cancer cells. The cancer is a mass of cells in a state of furious growth, and it invades and destroys the natural tissues all around it. The cells of the cancer show all stages of cell-division, and Professor Farmer finds in these stages the peculiarities which properly belong to reproductive cells only. In particular the number of nuclear loops is only half the number present in the cell-divisions of healthy tissue.

Professor Farmer is a botanist, and is distinguished for his researches in the microscopic structure of the cells of plants. It is a remarkable fact that in the processes of cell-division, reproduction, and fertilisation, the transformations seen in plant cells are essentially the same as in animal cells. The formation of the pollen of a flower in the stamens affords an example of the reduction of the number of the nuclear loops above mentioned to half the number proper for the plant. Only after the pollen nucleus has united with another in fertilisation is the full number regained. Again, a fern produces not seeds but spores. The nucleus of one of these spores contains only half the proper number of nuclear loops, and the divisions of the space which form the green flat growth preceding the development of the fern present the peculiarities which have now been observed in cancer. The theory suggested, therefore, is that cancer is the abnormal formation of reproductive tissue in parts of the body where no such tissue should be, or in certain cases the abnormal behaviour of reproductive cells in their natural position; the peculiarities of such cells being associated with a tendency to rapid division.

The theory, if true, does not completely solve the problem. The question still remains, What are the causes of this outbreak of peculiar activity in the cells; how can we prevent it and guard against it? The most plausible suggestion at present is that some chemical compounds are produced in the body which stimulate and excite the cells to this insane and destructive fury, and we still have to discover whether this is true, and whether the stimulation can be prevented or stopped. It is something, however, to have more light on the nature of the disease, to be investigating in the right direction. Something is already known of the stimulation of cells to division by means of reagents, and it ought to be possible to discover some antidote to the tendency to division. Surgery is our only remedy at present, and is sometimes very successful; but there is always the possibility that the unknown causes may continue at work, and develop new centres of cancerous activity.

Zoological Notes.

By R. LYDEKKER.

Similarities of Elephants and Dugongs.

AT the conclusion of his memoir on the evolution of the Proboscidea, recently published in the *Philosophical Transactions*, Dr. C. W. Andrews directs attention to certain very remarkable resemblances existing between the elephants and their extinct allies (Proboscidea) on the one hand, and the manati and dugong (Sirenia) on the other. Among the features common to the two groups are the non-deciduate and zonary placenta, the abdominal testes, the pectoral position of the mammæ, the bifid apex of the heart, the general absence of a foramen in the lower end of the humerus, and a remarkable similarity not only in the form of the molars, but likewise in the mode of succession of these teeth, which are pushed forward in the jaws with advancing age. Whereas, however, in the Sirenia this pushing forward is due to the development of additional teeth at the back of the series, in the Proboscidea it is caused by a progressive increase in the size of the individual teeth from front to back. In both cases the anterior molars are shed as they become worn out. Other resemblances between the two groups exist. Although the evidence is far from being conclusive, yet it is strongly in favour of a relationship between sirenians and proboscideans, albeit at a very remote epoch.

* * *

Fossil Reptiles.

In a recent issue of the *Philosophical Transactions*, Mr. G. A. Boulenger describes some interesting reptilian remains from the Triassic sandstone of Lossiemouth, near Elgin. They include a remarkably fine skull of *Hyperodapedon*, which shows the structure of the palate better than in any other known specimen. The main difference from the corresponding aspect of the skull of the existing tuatera (*Sphenodon*) of New Zealand, apart

from the dentition, is to be found in the smaller bony roof of the mouth, and the narrower vomers. Another skull, which is made the type of a new genus and species, under the name of *Stenometopon taylori*, comes still nearer to the tuatera. Other specimens show that the reptile previously described as *Ornithosuchus* is not, as originally supposed, a dinosaur, but is more nearly related to *Phytosaurus* (*Belodon*), which latter Mr. Boulenger, like the author of the under-mentioned memoir, thinks should be removed from the Crocodilia to an order apart.

* * *

Classification of Reptiles.

An extremely important memoir on the classification of reptiles is published by Professor H. F. Osborn, in the *Memoirs* of the American Museum. Following the lead of certain other writers, the author proposes to divide reptiles into two main stems—Synapsida and Diapsida; the former including the primitive Cotylosauria, the mammal-like Anomodontia (exclusive of the American Pelycosauria), Chelonia (tortoises and turtles), and Sauropterygia (plesiosaurs), and the latter all the other groups. The one branch, it is urged, gave rise to mammals, and the other to birds. The main line of cleavage between the two branches is the single, or undivided, temporal arch (and the consequent presence of only one temporal vacuity) in the former, and the duplication of the same arch in the latter.

The divergence from the classification usually adopted in this country is not very great, if one factor be borne in mind. European writers usually classify animals according to their degree of evolution, while American naturalists prefer a phylogenetic scheme. That is to say, the former draw their lines of division horizontally, and the latter vertically. A case in point is afforded by the ancestry of the horse, treated in our last issue. American writers would include in the *Equidæ* all the members of the series down to and inclusive of *Hyracotherium*, whereas English naturalists place in that family only the really horse-like latter forms, while they would refer the earlier types to other families, among which would be embraced the ancestors of the tapirs and certain "non-adaptive" forms. Much may be said in favour of both schemes; which, instead of being opposed to one another, are in reality different aspects of the same view. * * *

Duration of Pregnancy in the Badger.

It is not a little remarkable that there should still be great doubt in regard to such an apparently simple matter as the duration of pregnancy in the badger. A writer in the December number of the *Zoologist* considers that the period is about 12 months, whereas another observer had some time ago put it at about 4½ months. Perhaps the true explanation may be that suggested in Sir H. Johnston's "British Mammals," namely, that the normal period is about six months, but that, as in the roe-deer, under certain circumstances, development may be so retarded as to make the time of gestation double that length. * * *

Evolution of Marsupials.

An important memoir by Dr. B. A. Bensley, on the evolution of Australian marsupials, has just been published in the *Transactions* of the Linnæan Society. In regard to the origin of marsupials generally, the author is of opinion that the vestigiary placenter of the vansicoots has been independently acquired, and is not therefore indicative of descent from placentals. Nevertheless, he admits the comparatively near relationship of placentals and marsupials. The latter are believed to have been primarily differentiated by the assumption of arboreal habits, and the earliest forms that can be definitely assigned to the group are the opossums, which thus form the stock of all the modern types, with the possible exception of the Tasmanian wolf, or thylacine. This arboreal radiation distinguishes marsupials from the extinct creodonts, which were terrestrial. At the same time, the thylacine, which it is suggested may have been a foreign immigrant into Australia, appears to be related to certain middle tertiary South American types (*sparasrodonts*), which may themselves be connected with the creodonts. How this fits in with the arboreal ancestry of the other marsupials is left unexplained.

That curious creature, the gigantic extinct *Thylacoles* of Australia, originally regarded by Owen as carnivorous, but considered by Flower as herbivorous, is reaffirmed to be a flesh-eater.

As regards the date when marsupials first reached Australia, there has been much difference of opinion, Wallace giving it as Jurassic, Spencer as Cretaceous, and Lydekker as Eocene; the author considers that it did not take place till Miocene times. Whether the route traversed was *viâ* the Malay Archipelago and Papua, or by Antartica, is left undecided. There are many other points of interest in the memoir, to which lack of space forbids allusion.

* * *

Death of Prof. Karl von Zittel.

Palæontologists throughout the world will hear with deep regret of the death of Professor Karl von Zittel, which took place at Munich from heart-affection. Professor Zittel is most widely known by his splendid Manual of Palæontology, of which a smaller edition was published as a Handbook. The latter has been translated into French, and two volumes of an English (somewhat modified and expanded) edition have also appeared. Much original palæontological work was also accomplished by the late Professor.

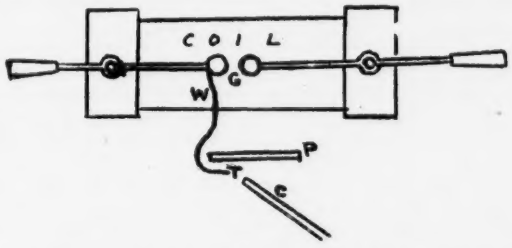
The Electric Eye.

Curious Experiments with Electric Sparks.

Mr. Walter J. Turney describes in the *Scientific American Supplement* some very interesting experiments showing results which he attributes to the ultra-violet rays of light. An ordinary half-inch Ruhmkorff coil has the knobs of its terminals so adjusted that sparking just fails to take place across the gap. On presenting a conductor to the inner side of either knob, vigorous sparking at once takes place and continues so long as the conductor remains, ceasing as soon as it is removed. If, however, a non-conductor be presented in the same way, a precise result, oddly enough, ensues. A piece of bare wire, W, about four inches long, was next attached to one of the knobs, and bent round as shown in the figure. If the conductor C be presented to the end, T, of the wire, continuous sparking will occur at the gap G. On now placing a screen, P, of cardboard, glass, or metal, so that G is invisible from T, sparking will cease, but will recommence so soon as the screen is removed. If, however, the screen be of rock-crystal, gypsum, rock-salt, or alum, the sparking will not be interrupted thereby. In another arrangement tried, a mirror was introduced to reflect the image of the junction on to the spark gap, with similar results, as though the spark could see what was going on.

A further modification was the introduction of a square

prism of rock salt, about three-quarters of an inch wide, as a screen. First this was turned so that one face was perpendicular to the line joining T to G. On placing the conductor near to T, vigorous sparking commenced at G. If the prism be then turned so as to present an angle, the vigour of the sparking will be diminished, even though the prism be moved slightly to one side so that the line joining the points would only traverse a small thickness of the rock-salt. The exact explanation of these phenomena is not clear. It seems evident that



light, which can be impeded, reflected, or refracted, is the origin of the effects shown. That they are not caused by ordinary light, however, seems to be the case, since the plates (three-quarters of an inch thick) of rock-crystal, &c., interrupt the communication. The author concludes that rays of ultra-violet light are the cause of the phenomena. This seems a promising field for investigation, as the apparatus is so very simple and easily applied.

The Altimeter.

WE have received from Messrs. Newton and Co. a list of their optical and other scientific instruments. Among their novelties is the Altimeter, which has been made to supply a want that has been felt among kite flyers and military balloonists. It is a simple form of aneroid barometer marked in figures for heights, and is so devised that the hand on the dial rests at the highest altitude obtained by the kite or other aeronautical machine on which it has been sent up. The scale tends to five thousand feet, and the full-sized instrument in an aluminium case weighs about seven ounces. Messrs. Newton mindful of the increasing price of radium, which makes even a few milligrammes of the metal an expensive luxury, have produced a radium screen, which is a sheet of glass coated with a mixture containing radium bromide in very small quantities. The largest sized screens cost half a guinea, and there are cheaper ones which are sufficient for showing many of the remarkable properties of the metal.

IT is not to northern China that one would usually look for an example of electrical progress, but there is at least one place on the eastern shore of the Liaotung Peninsula which might well set an example to many of the western towns. We refer to the city of Dalny, which lies near Port Arthur, in that portion of the Chinese Empire which was leased to Russia in 1898. Electrically, Dalny is up-to-date. It has both telephones and the electric light. The central station, which is considered the finest electric plant in Asia east of Singapore, was finished over a year ago. It is equipped with three of Ganz and Co.'s generators, with a total of 1000-horse power, and has a reserve space for additional machines to double its present capacity when required. Dalny, besides other things, is an important seaport, and has a dry dock 380 feet long, 50 feet wide, and 18 feet deep, which is equipped throughout with electric pumps. A larger dry dock is building, at which electricity will also be adopted. In connection with the dry dock are the harbour repair shops, with foundry, smithy, machine and fitting shop, boiler shop, etc. All these shops are electrically driven and lighted throughout. Dalny also boasts an excellent telephone service, and altogether it may fairly claim to be one of the most progressive cities in the East.

Continental Physical Notes.

By DR. ALFRED GRADENWITZ.

Researches in Solar and Stellar Photometry.

THE accurate data we possess as to the ratio between the intensity of the different stars are due to the work of several generations of astronomers. As regards, however, the ratio between the intensity of the sun and that of the stars, the results are far from being as satisfactory, the figures stated by different observers varying up to ratios as high as 1 and 10.

The knowledge of these ratios, as pointed out by Ch. Fabry (Eclair. Elec. No. 50), is, however, of the highest interest, allowing as it would of determining for stars the distance of which from the earth is given the ratio between their absolute candle power and that of the sun, and thus of classifying the sun, so to say, in the hierarchy of the stars.

As the light of the sun has a colour resembling closely that of most of the stars, a photometric standard of the same shade could be chosen, which is far from being the case in connection with our ordinary lamps. To this effect, Fabry projected the light of a glow lamp through a layer of an ammoniacal solution of copper sulphate; by regulating either the thickness or the concentration of the liquid layer, the emerging light could be given a tint strictly identical with that of the light of the sun. The photometric standard thus modified would be compared separately, both with the light of the sun and that of a star when the ratio $\frac{\text{Sun}}{\text{Wega}}$ was found to be about 6×10^{10}.

As regards the data relative to the illumination produced by stars in terms of our photometric standards, the results obtained are true only to within 10 per cent., on account of the difficulty inherent in the difference of coloration. According to Fabry, the illumination produced by the sun when in the zenith on the level of the sea is about 120·000 lux, being, as a matter of course, variable with atmospheric conditions, but to a smaller extent than might be anticipated, provided that only days of fine weather be considered. Photometric measurements will allow of ascertaining whether the sun is a variable star.

These researches will enable the photometric unit of astronomy to be connected to that of physicists. The intensity of a star should be measured by the illumination produced on a surface perpendicular to its rays, being expressed in lux. On the other hand, astronomers will define the same by its *magnitude*, the magnitudes of two stars differing by one unit, as the ratio of their intensities is 2 : 5, the most brilliant having the smaller magnitude. The following table records some comparative data of this kind:—

Star.	Magnitude.	Illumination in Lux.
Sun	− 26·6 ..	120·000
Moon	− 12·2 ..	0·2
Star first magnitude ..	+ 1 ..	$1{\cdot}05 \times 10^{-6}$
Star sixth magnitude ..	+ 6 ..	$9{\cdot}7 \times 10^{-9}$
Star fourteenth magnitude ..	+ 14 .	$6{\cdot}6 \times 10^{-12}$

As the most feeble stars visible to the naked eye are those of the sixth magnitude, one candle ceases to be visible to the naked eye at a distance of about 10 km., and a telescope showing stars of the fourteenth magnitude would allow of seeing a candle at a distance of 400 km. (apart from atmospheric absorption).

Electric Discharges in the Air.

In a paper read before the Angers Congress of the French Association for the Advancement of Sciences, Professor de Kowalski describes some experiments made by him, in conjunction with Mr. Mosciki, on the chemical action of high frequency electric discharges in gaseous mixture. With a certain frequency, a discharge through a gaseous medium is found to take a special character, which, by the way, depends also on the amount of electric energy available. The chemical actions of a similar discharge are very important from the

point of view of practical application, as in air an abundant production of nitrous vapors is observed; whereas in mixtures of carbonic gas and nitrogen both nitrous vapours and carbon monoxide are produced; with a mixture of benzine and nitrogen vapours, cyanogen and hydrogen will be obtained. On account of the importance of the problem in practice, Kowalski and Mosciki have especially dealt with the production of nitric vapours and hence nitric acid. They were able to obtain up to 44 grams of nitric acid per kw. hour, it appearing from their calculations that the price of one kg. of calcium nitrate would not be upwards of 1·3d.

De Kowalski next describes some experiments made on electric discharges on the surface of insulating bodies. As one side of the insulating plate is covered with a conductive layer while discharges are being produced on the other, sparks very much longer than without a conductive layer are obtained. Photographs presented by the author show the sparks to follow accurately the way drawn by conductive layer on the side of the plate opposite to the discharge, it being thus possible to obtain sparks of a triangular, square, zigzag, &c., shape. The author finally points out the analogies shown by the discharges with those produced in the atmosphere during thunderstorms.

On some Novel Phenomena in connection with N-Rays.

Professor Blondlot actively continues his investigations of N-rays. and in a paper recently read before the French Academy of Sciences we note some interesting facts. The author has some time ago observed that sources of light would, under the action of N-rays, show an increase in brilliancy. Now Blondlot thought it interesting to test whether the same phenomenon takes place in the case of a body reflecting the light from an external source being employed instead of an illuminant proper. The following experiment was accordingly made: A ribbon of white paper, 15 mm. in length and 2 mm. in breadth, was fixed vertically to an iron wire support; the room being darkened, the paper ribbon would be feebly illuminated by projecting on the same, laterally, a beam of light given off from a small plane enclosed in a box where a vertical slit was provided. The N-rays from an Auer burner, traversing a rectangular slit in front of the above slit, would strike the paper ribbon. Now, if the rays were intercepted by interposing either the hand or a lead plate, the small paper rectangle would be darkened and its outline lose in distinctness; as soon as the screen was taken away again both the brilliancy and distinctness would reappear, this giving evidence of the light diffused by the paper ribbon being increased under the action of N-rays.

Now, the diffusion of light is a complex phenomenon, where regular reflection plays the part of an elementary fact. The author therefore thought of investigating whether the reflection of light is also modified under the action of N-rays. To this effect, a polished knitting needle of steel was placed vertically in the position formerly occupied by the paper ribbon; in a box completely closed but for a vertical slit at the height of an Auer lamp (shut by a screen of transparent paper), a flame was placed so as to illuminate the slit. When adjusting conveniently the eye in the slit, the image of the latter formed by reflection on the steel cylinder was distinctly seen; while the reflecting surface was struck by N-rays, when the action of the ray proved to strengthen the image. Similar results were obtained, replacing the needle either by a plain bronze mirror or a polished quartz surface. All these actions of N-rays require an appreciable time both to be produced and to disappear. On the other hand, no action of N-rays on refracted light could be observed, though various experiments in this direction were undertaken under many different conditions.

As the capacity of seizing small variations in candle power is rather different for different persons, these phenomena are nearly at the limit of perceptibility to some persons, who, only after a certain practice, will be able to seize them regularly and to observe them safely, whereas others will at once, and without the least difficulty, note the strengthening effect of N-rays on the candle power of a small illuminant. Now, as the author has recently observed the same phenomena, with considerably increased intensity, when replacing the Auer burner by a Nernst lamp, these phenomena may now be produced with such intensity as to be visible to anybody.

The Printing Telegraph

The Berlin Teletyping Central Station.

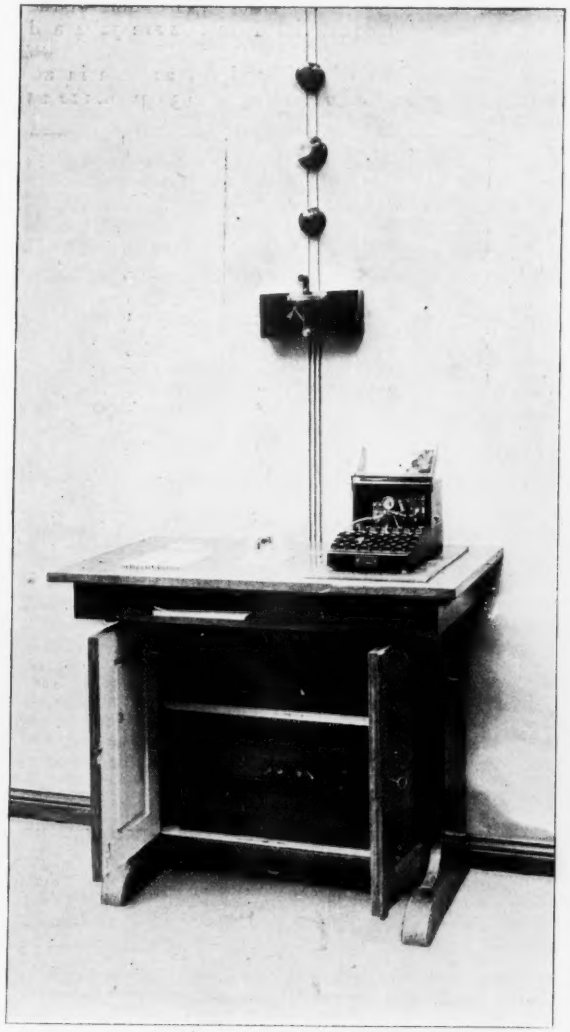
TELEPHONES, rendering only words as they are spoken, are frequently insufficient for business purposes; in addition to a correct transmission of a communication, there will in many cases be necessary an acknowledgment in writing of this transmission. On the other hand, there is the liability of telephonic conversation to be overheard by a third person, and finally the person rung up on the telephone may happen to be absent, when his return will have to be waited for, and much time be lost. In order to afford an efficient means of communication in all these and many other cases, a new public printing telegraph service was installed in Berlin on Oct. 1st, when the "Ferndrucker Centrale" was opened to public service.

The telegraph, as constructed by the Siemens and Halske Company, is a type-printing telegraph similar to the well-known Hughes type printer and the Baudot telegraph. The main distinctive feature from former apparatus is, however, the fact that the latter moving freely, the simultaneous working of the instruments established on the same line had to be obtained by the skill of the operator, whereas the operation of the new apparatus is as simple as that of an ordinary typewriter. The apparatus, in fact, is nothing else than a teletypewriter, any letters, figures, or signs of punctuation being printed by pressing down a key corresponding with the signal in question. There are two circles of signs on the periphery of the type wheel, one comprising the letters and the other the figures and signs of punctuation. A shift key serves to adjust the type-wheel either for letters or figures. Both sets of apparatus, connected by a line, may be used either as sender or as receiver, without any special preparation being necessary, as soon as a special white key is struck; the apparatus in question is in fact made to serve as sender, and all will be ready for use. The printing takes place simultaneously in both the transmitting and receiving apparatus, no matter whether there is or is not somebody operating the receiving apparatus. In the case of the owner of the apparatus being absent, he will read the telegram printed on the paper ribbon on his return. The new telegraph, giving two identical records of the same telegram in the sending and receiving apparatus respectively, will place at the disposal of the transmitter an evidence of the correctness of his communication, so as to exclude any possibility of misunderstanding.

The advantages afforded by the printing telegraph, as compared both with telephone and present telegraph system, will be self-evident. Like the telephone, the new telegraph may serve for a direct communication between any two persons over any distances, but for its being free from any possibility of hearing mistakes or other misunderstanding, in virtue of the double simultaneous reproduction in printing of each communication. At the same time, there is, as above stated, no danger of a third person overhearing the communications. This is therefore the only means of communication enabling despatches *to be kept strictly private.*

A central station with arrangements and working methods similar to those of central telephone stations has been opened in 28, Zimmerstrasse, Berlin, serving in the first place to secure mutual communication between all the subscribers connected to the Berlin printing telegraph net. The central station is fitted with a switchboard comprising indicators and cathices for one hundred sub-

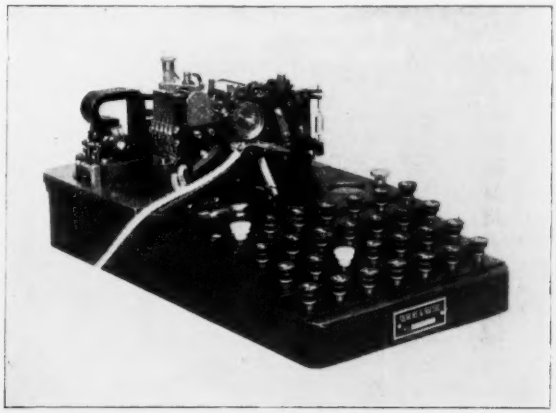
scribers. Sixteen connecting strings allow of 32 subscribers being simultaneously connected so as to enable a simultaneous communication between one third of all the subscribers in the case of the switchboard being complete. As soon as a subscriber presses down the calling key of his printing telegraph, the official in charge of the indicator board at the central station will be advised by the indicator of the subscriber in question dropping and an alarum being rung, when he will have to put himself in communication with the caller, to ask him for the desired connection through a special enquiring apparatus, and connect both subscribers so that their apparatus are



ready for immediate mutual communication. There is, however, in addition, the possibility of connecting any desired number of subscribers to the same printing telegraph so as to transmit the same communication simultaneously to all the subscribers. This is ensured by the subscribers who, as a rule, are connected to the indicator board of the central station, being disconnected from the latter and connected to the transmitting apparatus in question by means of a group switch.

Similar telegraphic services from one central station to a certain number of subscribers simultaneously, by means of a so-called ticker, have for some time been used in New York, London, and Paris. A similar service has been in operation also in Bremerhaven, Germany, for transmitting ship telegrams from one central station to 100 subscribers in different places. It is intended, from the central station just opened in Berlin, to transmit similar information to a certain number of subscribers, limiting the service at first to Exchange telegrams, which are transmitted at given hours from the transmitting apparatus in the Berlin Exchange. The same means of communication could be employed for transmitting telegrams from a central telegraph office, such as Reuter's, to a certain number of newspaper offices. In addition, the above central station is intended to secure communication of the subscribers with the central State telegraph office for transmitting or receiving telegrams through the State telegraph, for which subscribers are charged a rather low extra fee of so much per word.

The main feature will, however, be the *direct mutual communication* between the subscribers, and in this respect Berlin may boast of having quite a unique means of communication. The system has, by the way, been in operation for some time with great industrial concerns such as the Berlin Allgemeine Elektricitäts Gesellschaft and the Siemens and Halske Company for communication between their various business departments.



In addition to the type-printing telegraph used in connection with the teletyping service described in another note, the Siemens and Halske Company have just brought out another kind of printing telegraph, intended for rapid service. The apparatus is analogous to the so-called automatical telegraph, where an apparatus similar to a typewriter pierces for each letter to be telegraphed certain holes in a continuous paper ribbon. The latter, on being drawn along through the rotating telegraphic sender, will throw automatically corresponding currents into the line. As the Siemens apparatus is capable of telegraphing 2,000 letters per minute, the telegrams transmitted by a large number of officials will be sent on the same wire. Two holes are pierced for each letter, the letter itself being printed immediately above in plain ordinary printing characters. The perforating may even be effected by the public itself. A disc, where the various letters are cut out as in a pattern, rotates at a speed of 2,000 revolutions per minute, between a spark gap and a continuous ribbon of photographic paper. Whenever a spark passes in the gap, a silhouette of the letter happening to be in front of the gap will be projected on the paper ribbon, which on running through sponges impregnated with developing and fixing liquids, will complete the photographic process.

A. G.

XUM

The Face of the Sky for February.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the sun rises at 7.43, and sets at 4.45; on the 29th he rises at 6.50, and sets at 5.36. The sun is after the clock, the equation of time reaching a maximum of 14 m. 25 s. on the 12th.

Sun spots may frequently be observed; of late, the solar disc has rarely been devoid of spots. For determining spot positions the appended table should prove useful

Date.	Axis inclined to W. from N. point.	Centre of disc, S of Sun's equator.
Feb. 5 ..	13° 38′	6° 21′
,, 15 ..	17° 20′	6° 52′
,, 25 ..	20° 28′	7° 10′

THE MOON:—

	Phases.	H. M.
Feb. 1 ..	○ Full Moon	4 33 p.m.
,, 8 ..	☾ Last Quarter	9 56 a.m.
,, 16 ..	● New Moon	11 5 a.m.
,, 24 ..	☽ First Quarter	11 9 a.m.

The Moon is in perigee and apogee at midnight on the 1st and 15th respectively. Occultations.—It will be seen from the particulars below that there is the interesting phenomenon of an occultation of the 1st magnitude star Aldebaran, and, morevover, the circumstances are most favourable as the moon is near the meridian.

Date.	Star's Name.	Magnitude.	Disappearance.	Reappearance.	Moon's Age.	Moon Souths.
					D. H.	
Feb. 24	Aldebaran	1·1	5.57 p.m.	7.15 p.m.	8 7	6.17 p.m.
,, 29	o Leonis	3·8	8.53 p.m.	9.46 p.m.	13 10	11.6 p.m.

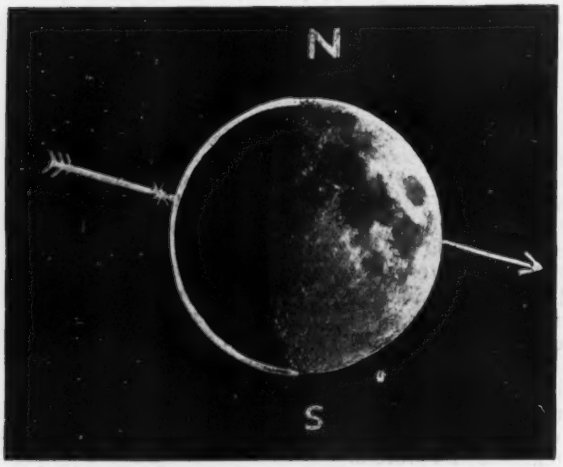


Diagram Illustrating Occultation of Aldebaran.

THE PLANETS.—Mercury is a morning star in Sagittarius; on the 10th, when he is at greatest westerly elongation, he rises 1 hr. 10 min. in advance of the sun.

Venus is a morning star, rising throughout the month about 5.40 a.m.; she continues to diminish in brightness and is becoming more gibbous, about 0·80 of the disc being illuminated.

Mars continues to be feebly visible in the south-west shortly after sunset; throughout the month he sets about 7.30 p.m.

Jupiter is rapidly getting more to the west and also diminishing in brightness; on the first he sets at 7.27 p.m., and on the 29th at 7.40 p.m. About the middle of the month his polar and equatorial diameters are 32″·4 and 34″·6 respectively.

The configurations of the satellites as seen in an inverting telescope, and observing at 6.30 p.m., are as follows:—

Day.	West.	East.	Day.	West.	East.
1	1⊙34		16	24○13	
2	2○134		17	1○43●	
3	○234●		18	⊙324	
4	1○324		19	32○14	
5	32○14		20	321○4	
6	31○24		21	3○124	
7	3○1$\frac{4}{2}$		22	13○24	
8	1⊙23		33	2○134	
9	42○13		24	12○43	
10	4○23●		25	4○1$\frac{3}{2}$	
11	41○32		26	432○●	
12	432○1		27	4321○	
13	4321○		28	43○$\frac{2}{1}$	
14	43○12		29	413○2	
15	41○2●				

The circle (○) represents Jupiter; ⊙ signifies that the satellite is on the disc; ● signifies that the satellite is behind the disc, or in the shadow. The numbers are the numbers of the satellites.

Saturn is in conjunction with the sun on the 1st, and therefore unobservable.

Uranus rises only a short time before sunrise; this, together with his extreme southerly declination, makes him most unsuitable for observation.

Neptune souths at 9.30 p.m. on the 1st, and at 7.30 p.m. on the 29th. He is about half a degree S.E. of μ Geminorum and his path is shown in the chart given in the January number.

Meteor Showers:—

Date.	Radiant.			Characteristics.
	R.A.	Dec.	Near to.	
Feb. 5-10	75°	+ 41″	η Aurigae	Slow; bright.
,, 15	236	+ 11″	α Serpentis	Swift; streaks.
,, 20	181°	+ 34″	Cor Caroli	Swift; bright.

THE STARS.—The positions of the principal constellations near the middle of the month at 9 p.m. are as follows:—

ZENITH . Auriga.

SOUTH . Orion, Gemini, *Procyon*, *Sirius*, Cetus, Pleiades, Taurus to the S.W., Cancer and Hydra to the S.E.

WEST . Andromeda, Aries, Pisces, with Pegasus and Cygnus to the N.W.

EAST . Leo, Virgo.

NORTH . Ursa Minor, Draco, Cepheus, Ursa Major to the right of Polaris.

Minima of Algol may be observed on the 1st at 11.52 p.m., 4th at 8.41 p.m., 7th at 5.30 p.m., 22nd at 1.35 a.m., 24th at 10.24 p.m., and the 27th at 7.13 p.m.

Telescopic Objects:—

Clusters.—M35, situated about 2° N.E. of η Geminorum or about midway between ξ Tauri and ϵ Geminorum. Fairly compact, presenting a beautiful appearance of star streams when observed under favourable conditions. R.A. VI.^{h} 3^m Dec. N. 24° 21′ N41, about 4° directly south of Sirius; visible to naked eye; Messier registered this group as "a mass of small stars," R.A. VI.^{h} 43^m Dec. S. 20° 38′ M44, the Præsepe in Cancer, visible to the naked eye as a nebulous patch, best seen and easily resolvable with a pair of opera or field glasses. On account of the scattered nature of the group the cluster effect is lost when observed through a telescope unless very low powers be employed. Situated a little to the west and about midway of the line joining α and δ Cancri. R.A. VIII.^{h} 34^m Dec. N. 20° 20′.

Double Stars.—*Castor*, separation 5″·8, mags. 2·7, 3·7. Excellent object for small telescopes. The brightest pair to be observed in this country; can always be relied upon as a good show object.

κ Geminorum, separation 6″·3, mags. 4, 8·5; very pretty double.

ξ Cancri, separation 1″·1, 5″·3, mags. 5·0, 5·7, 5·5; with small telescopes the wider component is readily seen.

γ Draconis, separation 61″·7, mags. 4·6, 4·6; a pretty and easy double, can be separated by observing with a pair of opera glasses.

The Shower of November Leonids in 1903.

TO THE EDITORS OF "KNOWLEDGE."

GENTLEMEN,—At the end of my paper under this heading, published in the January number of "KNOWLEDGE," I referred to a second magnitude meteor seen at 15 hrs. 59 mins. on November 15, and moving in a long and slowly traversed path from a probable radiant at 113°−34°. Two of the observations from which the real course was deduced were, however, somewhat imperfect and indefinite. Fortunately I have since received a description of the object as seen at Greenwich at 15 hrs. 59 mins. 38 secs., and I have recomputed the heights and radiant. The latter position was really in Hydra at about 147°−11°, and the height of the meteor varied from 91 to 45 miles during its extended flight of 128 miles, which it pursued at the rate of 29 miles per second. The object certainly travelled at a much slower speed than is consistent with a parabolic orbit.

Professor Herschel has recently been comparing the recorded paths observed on the night of November 15 by several observers, and has found a few interesting accordances. Two of these were of brilliant Leonids, and the real courses which I have calculated for these agree very closely with the results previously obtained by Professor Herschel, and are as follows:—

Date and Greenwich mean time of the observations..	November 15 16 hrs. 45½ mins.	November 15 18 hrs. 7 mins.
Estimated magnitudes ..	4 — 0 +	>1 — 4
Radiant point	151 + 25	151 + 23
Height at beginning ..	77 miles	81 miles
Height at ending	52 ,,	60 ,,
Length of visible path ..	30 ,,	24 ,,
Velocity per second.. ..	60 ,,	44 ,,
Observers	A. S. Herschel, Slough. W. F. D., Bristol.	A. S. Herschel, Slough. A. King, Sheffield. W. F. D., Bristol.

Notwithstanding the richness of the Leonid shower in 1903, and the large number of observations, comparatively few of the same meteors appear to have been seen at two stations.

Bishopston, Bristol, January 6, 1904.

Yours faithfully,
W. F. DENNING.

MICROSCOPY

Conducted by F. SHILLINGTON SCALES, F.R.M.S.

Magnification of Objectives and Eyepieces

IT is scarcely necessary to explain to any worker with the microscope that, whereas a simple lens gives a single magnification only, the essential principle of the compound microscope is that the image formed by the first lens or system of lenses, called the objective, is itself again magnified by a second lens or system of lenses known as the eyepiece, or ocular. But, simple as this is in principle, the means by which it is brought about, and the various points connected therewith, are often not fully understood by ordinary workers, many of whom are not clear as to the exact meaning of such terms as one inch, half-inch, &c., as applied to objectives, or to references to angular aperture as compared with numerical aperture, aplanatic aperture, &c.

Briefly, the principle on which objectives are rated is as follows: We have here a lens, or system of lenses, with which we form our first magnified image, and this image is formed at a definite distance from the back of the lens. According to English standards, this distance is 10 inches, which was originally adopted as being the the normal visual distance of the human eye. Then it follows that the relative size of object and image will vary directly as their respective distances from the lens, or rather from its centre. Accordingly, if the two distances are 1 inch and 10 inches respectively, the initial magnification will be ten times, and here we have our 1-inch objective. If the distances are 2 inches and 10 inches, the magnification will be five times, and the objective will be known as a 2-inch. If the distances or foci are ½ inch and 10 inches, the magnification will be twenty times, and the objective is ½ inch, whilst a 1-12th inch objective magnifies initially 120 times.

On the Continent, however, the image comes to a focus about 6½ inches behind the objective, this being the Continental tube-length, but the rating seems to generally remain the same—the 1-inch magnifying 10 times at 10 inches, the 2-inch 5 times, and so on. Thus a Continental 1-inch objective used with a 6½-inch tube should only give an initial magnification at this distance of 6·5 diameters. As a matter of fact, however, objectives are nearly always overrated, sometimes absurdly so, and therefore a Continental 1-inch may give an initial magnification exceeding 10, even with the short tube.

Of course the tube-length of a microscope can generally be varied, and the result will be in the first place a readjustment of focus and a consequent variation in the magnification. But the second result is that, as objectives are not meant to be used for uncovered objects, they have been carefully "corrected" for a certain definite thickness of cover-glass. The Royal Microscopical Society has used its powerful influence to bring makers into line throughout the world with regard to the standardizing of the screw of objectives, the diameters of eyepieces, and the size of sub-stage condensers, and it would be a great advantage if it could also standardize the thickness of cover-glass to which objectives are corrected. Perhaps this may be done some day; in the meantime

each maker, whether English or foreign, is a law unto himself, and the list of cover-glass corrections is a most formidable one. But it follows that any variation in cover-glass thickness from that for which the objective was originally corrected necessitates a readjustment either of the lenses of the objective, by means of a "correction collar," or by adjustment of the length of the microscope tube. In the latter case, of course, we have at once a variation of initial magnifying power, but the converse also applies, *i.e.*, that an arbitrary variation of tube-length affects the corrections, and consequently the performance of the objective. We can at once see the limitations, therefore, of the ordinary suggestions as to varying the magnification by drawing out or pushing in the draw-tube of the microscope. With low powers of small angle the difference in performance is not marked, and would even need a trained eye to detect it, but it becomes more and more marked with an increase of angular aperture, which generally coincides with higher powered objectives. Broadly speaking, therefore, we must use our objectives with the tube-length for which they were originally constructed.

The part played by the ocular—at least by the Huyghenian type of ocular which is generally used and with which we need only concern ourselves here—is twofold. It consists of a field-lens and an eye-lens, with a diaphragm between. The field-lens may really be considered almost as part of the objective, for its action is to draw in the image rays and bring them to their final focus in the plane of the diaphragm just mentioned. Then the eye-lens merely magnifies this image and brings it to a focus suitable for the eye.

It is important to note, therefore, that the magnification of any unadjustable ocular is always a fixed quantity, but that the magnification of an objective (perfection of image apart) will vary according to the tube-length. In spite of this, many Continental and some English makers persist in treating the two magnifications as if it were the ocular magnification which varied, thus giving rise to no little confusion. I have seen lists in which elaborate tables have been made of the combined magnifications of objectives and oculars used with a 6½ inch tube, in which the ocular has been treated as the varying quantity, and I have seen calculations of magnifications of objectives in one and the same table in which an inch or other objective is treated as magnifying 10 times and in another 7 times, at 6½ inches distance, the real fact being that the oculars are not of the powers they profess to be. All this is, of course, very confusing to the beginner.

Now, focuses do not represent "working distance." This merely represents the clear space between the cover-glass and the front surface of the objective, and can be measured by a carefully made wedge of wood which is inserted when the objective is focussed, marked, and then measured.

Nor is it necessary for us to work out with mathematical accuracy the exact equivalent foci of objectives, which are made up of complicated systems of lenses. This would be a difficult matter. It will be sufficient for us to obtain the approximate equivalent focus—approximate because the centre of the system cannot be readily obtained. If we set up conjugate foci at equal distances from the centre of the lens, the object and image will be of the same size, and conversely if the object and the image are the same size the distances of the conjugate foci are identical. This, of course, means that object and image are both *beyond* the principal focus; in fact they are at a distance just as much again as is the principal focus, *i.e.* they are on each side twice the distance of the principal focus from the centre of the lens. Therefore, the equivalent focus can be obtained by projecting the image of a brightly illuminated object upon a screen at such a distance that both image and object are equal, and dividing the total distance by four. Having obtained the equivalent focal length, we can easily calculate the magnification with any tube-length.

It is, however, with the magnifying power that the microscopist generally needs to concern himself, and this known, the equivalent focus can be easily obtained. Perhaps the easiest method of obtaining this is that mentioned in Carpenter. A micrometer slide ruled in hundredths and thousandths of an inch, or in tenths and hundredths of a millimetre, is placed upon the stage of the microscope, and the latter inclined to the horizontal position. A strong light is transmitted through the microscope, and the room darkened. The micrometer lines are then focussed sharply upon a piece of white cardboard placed five feet (60 inches) behind the *front* lens of the objective. The divisions on the screen are measured with an ordinary foot or millimetre rule and the result divided by 6, which gives, of course, their size at 10 inches from the objective. The value of the original stage micrometer divisions being known definitely beforehand it is easy to calculate the resulting magnification. Suppose the distance between the micrometer rulings of two 1-1000 of an inch to measure 1¼ inches at 5 feet distance with a nominal 1 inch objective. Then at 10 inches distance they would measure ·2083 inch, which is equivalent to an initial magnification of nearly 10½ times. A millimetre scale or rule can be used on the basis of 25·4 millimetres to an inch. Magnifications are always expressed in diameters, or linear measurements, not in areas. A considerable distance such as the above is taken so as to reduce the amount of error due to the fact that the measurements should really be taken from the principal posterior focus of the objective, which in a compound system cannot easily be found. But by measuring from the front lens as above a very small margin of error is left. It is best to take the mean of several micrometer divisions as they are not quite accurately ruled.

Combined magnification of objective and eye-piece is calculated by a similar method except that there is not the same necessity for taking a longer distance, and the image of the micrometer must be accurately projected exactly 10 inches from the eye-lens of the eye-piece. This may be done either direct by means of a photographic camera or otherwise, or at right angles by means of a Beale's camera lucida, to a piece of paper placed on the table, the microscope being raised if necessary to the requisite height so as to get the exact distance of 10 inches *from the eye-lens*. Short-sighted observers may therefore need to use spectacles in order to see the lines on the paper.

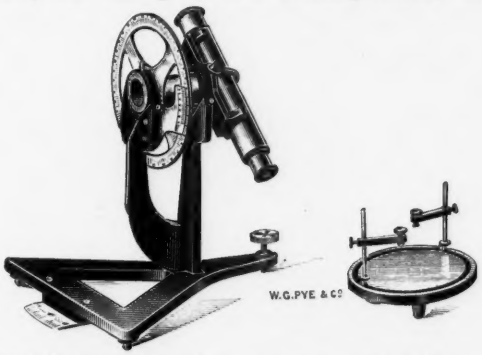
The eye-piece magnification is readily calculated by dividing the combined magnification by the initial magnification of the objective, independently determined. It will be noted that the result, as calculated, gives the magnification with a 10-inch tube; any other length is easily calculated—a 7-inch tube giving an initial magnification of 7-10ths of the result as above obtained, and the eye-piece magnification remaining constant for each eye-piece. One further explanation is perhaps necessary. We have hitherto been dealing with a total magnification calculated for a visual distance of 10 inches from the eye-lens, this being the normal visual distance, but it is as well to bear in mind that in actual practice an abnormal eye will form its image nearer or further away, according to whether the eye be short or long sighted. This will, of course, proportionately affect the magnification of the eye-piece, and, in consequence, the magnification of an

object as seen through the microscope by such an observer.

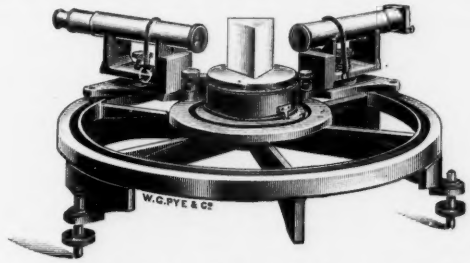
In making calculations connected with focal lengths the most useful formula is $\frac{1}{p} + \frac{1}{p^1} = \frac{1}{f}$ where p and p^1 denote the conjugate foci, and f the principal focus. When we know the size of the image and its magnification, and one of the two foci, such as 10 inches, we can use the proportion $D : d :: p^1 : p$, where D is the diameter of the image, d of the object, and p_1 the longer of the two foci, then, from the equation given above, *i.e.*, $\frac{1}{p} + \frac{1}{p^1} = \frac{1}{f}$, and the ratio $\frac{D}{d} = \frac{p^1}{p}$, we obtain $\frac{1}{f} = \frac{1}{p^1} \cdot \frac{D + d}{d}$, or more simply $f = p^1 \cdot \frac{d}{D + d}$.

New Spectrometer Table.

Messrs. W. G. Pye and Co., of Cambridge, have recently brought to my notice a new combination spectrometer, the adjustments of which present quite new features, and which might, I think, be adapted to certain microscopic accessories. All motions and fittings are arranged geometrically. The base consists of a heavy iron casting on three levelling screws, having



a true lathe-turned surface, with two annular V-grooves in it, one near the outer edge, the other a few inches from the centre. The telescope and collimator are provided with tables or carriages consisting of two pieces each, the lower part having two steel balls and one levelling screw for the feet. The balls work in the larger of the two annular grooves mentioned above, and the levelling screw on the plane surface a few inches from the centre.



The upper part consists of a cradle having two V-supports in which the telescope or collimator, as the case may be, lies evenly, being held in position by a spiral spring trap. This cradle being clamped by a thumbscrew to the lower part provides the necessary adjustment for getting the telescope and collimator into horizontal alignment. The V-fittings admit of almost any telescope and collimator being used. The two parts of the carriage are worked up mechanically true, so that very little adjustment is needed to set them optically true after the base has been levelled, which can be done by using a spirit level in the usual manner. The carriage for the telescope is provided with a vernier, whilst the one for the collimator has an index pointer only. The prism-plate consists of two parts, the upper of which is capable of adjustment in the horizontal plane without affecting the lower part, which has three spherical ended feet, two resting in the inner V-groove, the other working on the plane surface. The simplicity of the arrangement, and the easy way in which it can be worked up mechanically, combined with its steadiness and large bearing surfaces struck me favourably, and as the arrangement could easily be adapted to a reading telescope, to say nothing of adaptations to a model theodolite and sextant, circular vernier, simple dividing engine, &c. I trust its description will not seem out of place here. This instrument, when shown at the Royal Institution on April 3rd last, drew, I understand, considerable attention.

Recent Patents.

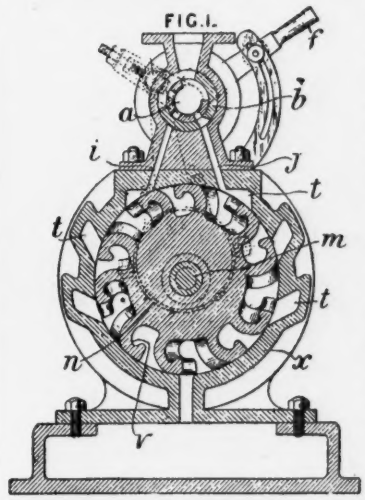
19,750. Natural history specimens, preserving. MATUSOVITS, P., Liptoujvár, Hungary. Sept. 9.

Beetles are preserved in a manner which keeps the joints flexible by treatment with a fluid consisting of specified proportions of alcohol, salicylic acid, sal-ammonia, and distilled water, to which arsenic or other substances may be added. The quantity of ammonia to be added depends on the colour of the beetle to be preserved. When thoroughly impregnated, they are placed in a cool closed chamber, to dry, the joints being bent from time to time while the beetles are being dried. The liquid may also be employed in preserving diptera, rhynchola, &c.

19,804. Hydrocyanic acid and cyanides. WOLTERECK, H. C., 3, Edinburgh Mansions, Howick Place, Victoria Street, London. Sept. 10.

A gaseous mixture of, preferably, equal parts of ammonia, a carbon compound, and hydrogen is passed over a suitable catalytic agent, such as platinized pumice, strongly heated and contained in a reaction chamber or series of chambers. The hydrocyanic acid may be collected, or it may be absorbed in caustic potash or soda to produce a cyanide. The carbon compound may be carbonic oxide or acid, or benzene, acetylene, ethyl or methyl alcohol, &c. Water gas may be employed for supplying a mixture of carbonic oxide and hydrogen. The gases or vapours should be free from water. The Provisional Specification states that freshly-reduced iron may form the catalytic agent.

19,823. Turbines or impact-wheels. MACARTHUR, C., and SMITH, F., both of 75, Church Road, Woolston, near Southampton, Hampshire. Sept. 10.

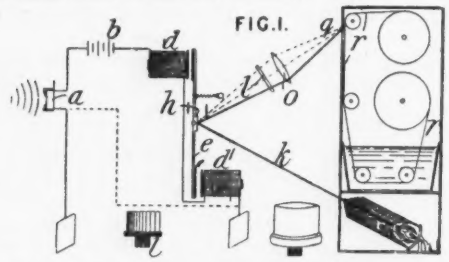


Relates to impact-wheels driven by expansible fluid pressure, and suitable for propelling ships. The impact-wheel has vanes *v* sloping in opposite directions alternately and of a corrugated or other curved cross-section. The fluid pressure is admitted twice during each revolution by means of a three-ported tubular valve *a*, which is rocked by an eccentric *n* on the main shaft *m*. The admission valve is surrounded by a ported sleeve *b*, which forms a reversing-valve, and which can be rocked by a handle *f* to admit the fluid to the port *j* for forward running or to the port *i* for backward running. Expansion chambers *t* are formed in the wall of the cylinder *x*.

XUM

19,901. Electric recording apparatus. HULSMEYER, C., 98, Bilker Allee, Düsseldorf, Germany. Sept. 11.

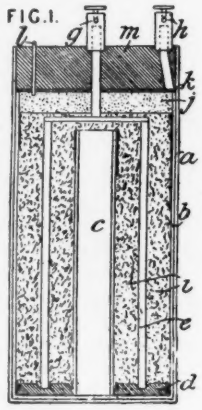
FIG. I.



Relates to apparatus for recording the variations of an electric current in the form of a photographic record produced by the variations in a beam of light. The particular example shown consists in imposing sound waves on a microphone *a* in an electric circuit including a constant battery *b* and magnet coils *d*, d^1. The armatures of the magnets are mounted on a spring-controlled pivoted mirror *e* carrying at its centre a mirror *h*. A beam of light *k* is reflected from the mirror on to a travelling photographic film *r* enclosed in a case having developing and fixing apparatus; *q* is a small opening in the case. The beam of light is varied by passing through an optical plate *l* of varying transparency from end to end, and is focussed on to the opening *q* by one or more prisms or cylindrical lenses *o*. The light-varying portions of the apparatus are adjustably mounted to allow of varying the sensitiveness. The record may be used for reproduction by causing it to vary an otherwise constant beam of light falling on a selenium cell in an electric reproducing circuit.

19,999. Secondary batteries. FIEDLER, L., 71, Huntley Street, Tottenham Court Road, and PUCHMULLER, G., 14, Mornington Crescent, both in London. Sept. 12.

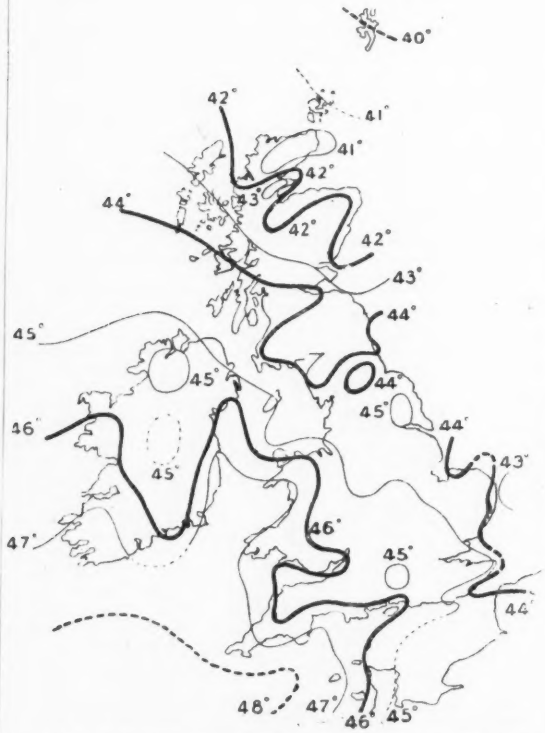
FIG. I.



Relates to the use of zinc as the negative plate. The battery consists of a papier-mâché box *a* containing a tightly-fitting zinc box *b*, which is connected with a second zinc box *c*, the two forming one electrode *h*. Upon the insulating-material, such as asphalt, which covers the bottom of the box *b*, the lead-peroxide anode *e* stands, and forms the other electrode *g*. The electrolyte *i* consists of a mixture of sulphuric acid, mercury sulphate, potassium ferro-cyanide, and zinc sulphate, and this forms a covering of zinc-mercury ferro-cyanide upon the zinc electrode, and protects it from the sulphuric acid when the accumulator is not in use. The electrolyte may be either liquid or rendered "dry" by an absorbent such as sawdust. The cell is closed in with a layer of sawdust *j*, a piece of cardboard *k* soaked in paraffin, and a layer of mastic material *m*, through which is an air pipe *l*.

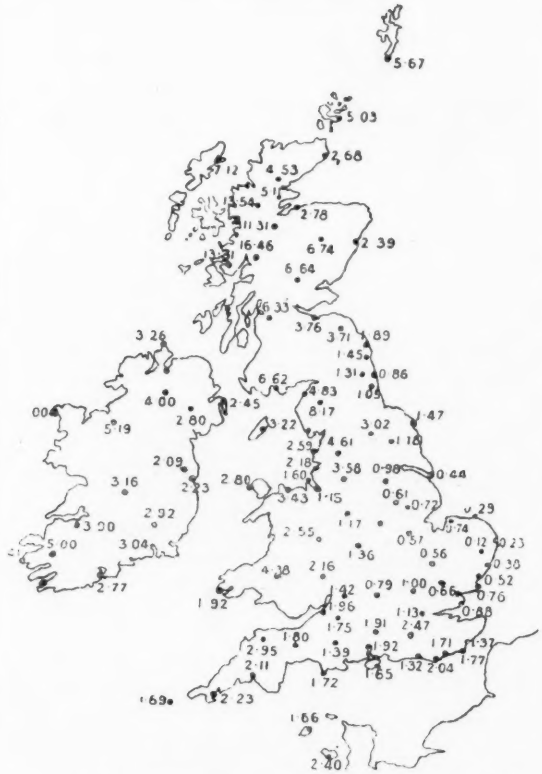
LAST YEAR'S WEATHER—FEBRUARY, 1903.

DISTRIBUTION OF MEAN TEMPERATURE.



Over the country generally the temperature was considerably above the average, the excess amounting to more than 4° in all districts, excepting the north of Scotland and the south of Ireland, to more than 5° in many parts of northern, eastern, and central England, and to as many as 6°·2 at York.

RAINFALL.



Rainfall was very deficient in the eastern, central, and southern parts of England, and also at some stations in the south of Ireland. In the western and northern districts generally there was a considerable excess, the amount at many of the Scotch stations being more than twice as much as the average.